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VOLUME 30, No. 3

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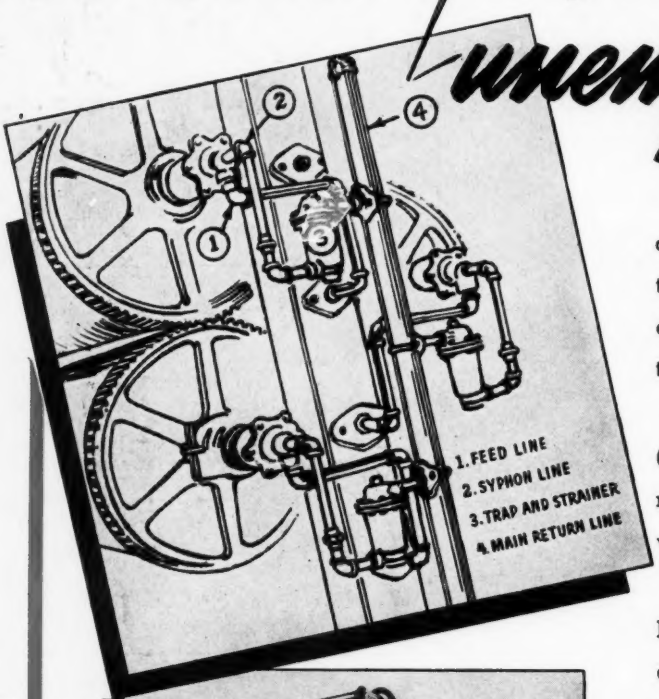

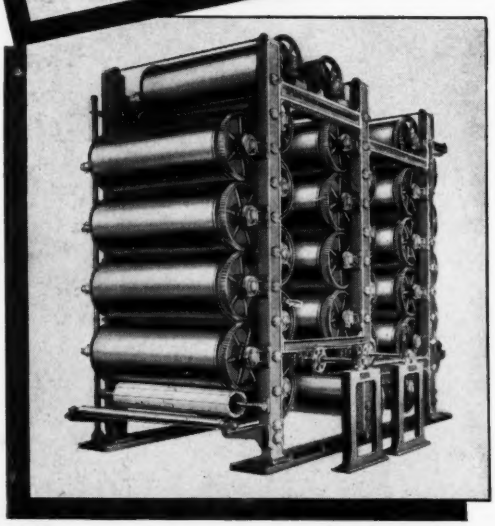

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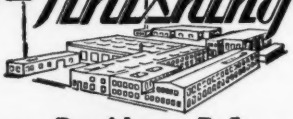

New York Office
50 Church St.

Southern Office
Johnston Bldg., Charlotte, N. C.

Providence, R. I.

American Dyestuff Reporter, Vol. 30, No. 3, February 3, 1941. Published every other Monday. Copyright, 1941, by Howes Publishing Co., 440 4th Ave., New York, N. Y. Domestic subscription, $5.00; Canadian, $6.00; Foreign, $6.00. Entered as second-class matter, Nov. 6, 1919, at the New York, N. Y., Post Office, under the act of March 3, 1879.

AMERICAN DYESTUFF REPORTER

A. P. HOWES
Publisher

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Official Publication of the Proceedings of the American Association of Textile Chemists and Colorists

FEBRUARY 3, 1941

VOLUME 30 NUMBER 3

American Dyestuff Reporter, Vol. 30, No. 3, Feb. 3, 1941. Published every other Monday. Copyright, 1941, by Howes Publishing Co., 440 4th Ave., New York, N. Y. Domestic subscription, $5.00, Canadian, $6.00, Foreign, $6.00. Entered as second-class matter, Nov. 6, 1919, at the New York, N. Y., Post Office, under the act of March 3, 1879.

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AMERICAN
DYESTUFF REPORTER

VOLUME 30 FEBRUARY 3, 1941 NUMBER 3

Microscopic Structure of the COTTON FIBER

CHARLES W. HOCK, ROBERT C. RAMSAY, and MILTON HARRIS*

PREFATORY ABSTRACT

During the examination of cotton fibers that had received various chemical treatments, a number of observations pertaining to the structural details of the fiber were made. Those phenomena which appeared to be new were investigated in detail. In addition, experiments described by earlier investigators were repeated in order to have a better composite picture of the structure of the fiber.

The cell wall of a cotton fiber consists of a primary and a secondary wall. The latter, which comprises the bulk of the fiber, consists of innumerable spirally oriented cellulose fibrils enclosed by a winding which also makes a spiral, but in the opposite direction from the former. Both the winding and the fibrils reverse their direction at frequent intervals along the axis of the fiber, their points of reversal being coincident. The secondary wall is enclosed by a thin primary wall. The latter is made up of fine criss-crossing strands of cellulose embedded in a membrane consisting principally of wax and pectic substance. The lumen also contains wax and pectic materials, plus various amounts of degenerated protoplasm.

When cotton fibers are swollen under certain conditions, a lamellate structure is discernible in the secondary wall. The number of these lamellae increases with the age of the fiber.

On treatment of cotton fibers with cuprammonium hydroxide reagent, the cellulose dissolves, leaving residues which vary in amount and in structure, depending upon the extent of purification of the fibers. The residue from raw and from dewaxed fibers consists of fragments of the primary wall, and of a lesser amount of material from the lumen. The behavior of the fibers in the reagent depends in part on their maturity. Immature fibers containing only small amounts of cellulose swell relatively little in the reagent, and the undissolved wax and pectic materials maintain the original tubular shape of the primary wall. When older fibers are given the same treatment they swell abruptly, thereby causing the primary wall to break in many places giving rise to "balloons."

Irregular swelling along the fiber axis, which results in the formation of balloons, appears to be dependent in part on the orientation of the fibrils, and in part on the constricting influences of the winding and of the primary wall.

I. INTRODUCTION

As part of a program of research relating to the chemical and physical structure of textile fibers, microscopic examinations were made of cotton fibers which had received various chemical treatments. A number of observations pertaining to the structural details of the cell wall of the cotton fiber were made. Those phenomena which appeared to be new were investigated in considerable detail. In addition, experiments described by earlier investigators (Balls[1, 2, 3], Denham[4], Sakostschikoff and Korsheniovsky[5], Kerr[6], Anderson and Kerr[7], Farr[8], and Barrows[9]) were repeated, and are reported here for the sake of completeness.

*Representing the Textile Foundation Research Associateship at the National Bureau of Standards.

II. MATERIALS

Two varieties of *Gossypium hirsutum L.*, Missdel-7 and Mexican Big Boll, were used in the investigation. Samples of each were furnished by the Agricultural Marketing Service of the U. S. Department of Agriculture. Missdel-7 was grown at the Delta Experiment Station, Stoneville, Miss. Only fibers from open bolls of this variety were used. The samples of Mexican Big Boll variety, grown at the Experiment Station at Raleigh, N. C., were from special case-historied material collected for joint fiber structural studies by the Bureau of Plant Industry and the Agricultural Marketing Service. The samples of the latter were principally young or immature fibers from bolls of known age. Fibers of different ages were obtained by tagging the flowers on the day of bloom-

ing and then collecting the bolls on successive dates so as to give material of the desired age. Two series of immature Mexican Big Boll fibers were used. One, collected during the summer of 1939, consisted of dried fibers in which deposition of secondary cellulose had begun. The other, collected during the summer of 1937, consisted of very young fibers with primary wall only. The second set of fibers was obtained from bolls, the locks of which, at the time of collection, had been placed in boiling water for a few minutes to untangle the fibers, and then stored in approximately 70 per cent ethyl alcohol.

Those fibers which received no chemical treatments are termed *raw fibers*. In the present paper the young Mexican Big Boll fibers which had been boiled in water and then placed in alcohol are also included in this category, although it is recognized that the treatment was not without effect on the composition of the fibers. The natural waxes were removed from some of the raw fibers by extraction with alcohol and ether for 24 hours each. These fibers are termed *dewaxed fibers*. A portion of the dewaxed material was further purified by extraction with alkali according to the method recommended for the preparation of standard cellulose. The procedure was essentially the same as that described by Corey and Gray[10] except that the apparatus of Worner and Mease[11] was employed. These fibers from which both wax and pectic substance were removed[12] are termed *depectinized fibers*.

Cuprammonium hydroxide solution was prepared according to the recommendation of Mease[13]. The solution contained 240 ± 5 g. of ammonia (NH_3), 15 ± 0.1 g. of copper, and 1.0 g. of sucrose per liter. The concentration of nitrite was less than 0.5 per cent. When not in actual use the cuprammonium hydroxide was kept under nitrogen in tightly stoppered bottles in the refrigerator.

Trimethylbenzylammonium hydroxide was used in some of the experiments. The stock solution, which was 2.5 *N*, was diluted with water just before using.

For staining cellulose, iodine and sulfuric acid[14], zinc chloride-iodine[14], and an alkaline solution of Congo red (0.5 per cent of dye in a 0.5 per cent solution of sodium hydroxide) were used. Aqueous solutions of ruthenium red were used for staining pectic compounds[15]. Although ruthenium red is not a specific stain for pectic substance, native pectic compounds invariably take a red color in the presence of this dye[7].

III. EXPERIMENTAL PROCEDURE AND RESULTS

The cell wall of the cotton fiber is composed of a primary and a secondary wall. The primary wall, in accordance with the description of Anderson and Kerr[7], is considered to be the outer sheath of the fiber, or the portion of the wall formed as the fiber increases in length. Secondary wall then refers to that part of the wall which is laid down after the fibers cease to elongate appreciably. Only the thin primary wall encloses the protoplasm of the cotton hair as the fiber elongates during the first 13 to 20 days after its origin. Thereafter, the thickness of the wall is increased by a deposition of cellulose which comprises the secondary wall. For convenience in discussion, these two distinct layers are considered separately.

1. Primary Wall

Young fibers, 3, 5, 8 and 15 days old, were mounted in water and examined microscopically. With ordinary light there was no evidence of structure in the thin primary wall. The walls stained deeply and uniformly with ruthenium red. When treated with an alkaline solution of Congo red, zinc chloride-iodine, or iodine and sulfuric acid, the fibers gave a faint color reaction. In older primary walls, for example in a 15-day fiber, an ill-defined pattern was observable in the wall.

On examination with crossed nicols, unstained fibers showed practically no birefringence. Insertion of a selenite plate between the nicols produced faint colors indicative of a predominantly transverse orientation. Although these fibers showed little birefringence when unstained, they were clearly anisotropic after treatment with a dye such as Congo red. This increase in birefringence upon staining is due, apparently, to the double refraction of the preferentially oriented dye molecules[16, 17].

When wax and pectic substance were removed from 15-day fibers the material which remained still had the outline of the original fiber, and stained with Congo red, zinc chloride-iodine, and iodine and sulfuric acid. Between crossed nicols the stained depectinized fibers were birefringent and showed a pattern like that in the stained walls of raw fibers. When the purified fibers were placed in cuprammonium hydroxide solution they appeared to dissolve completely in the reagent.

The stained walls of both the raw and the depectinized fibers were suitable for observing the cellulose* of the primary wall. In agreement with the description by Balls[2, 3], and by Anderson and Kerr[7], the cellulose, as observed with crossed nicols, was found to be present as criss-crossing strands. At 45° with respect to the planes of the nicols, the fiber showed its maximum brightness and presented a reticulate appearance (Fig. 1, A). When a fiber was rotated to the right or left of its position of maximum brightness, either one or the other of the systems of criss-crossing strands predominated the image (Fig. 1, B and C). Measurement† of the angles which these birefringent strands made with the axis of the fiber were made on fibers of different ages. The results indicated that the angle of orientation decreases with increase in age of the fiber. In other words, the orientation was more nearly transverse in the younger than in the older ones. Likewise, the netlike structure of the cellulose, when the fibers were placed at 45°, appeared coarser

*While the identity of this material has not been definitely established, X-ray investigations, staining reactions, and behavior in cuprammonium hydroxide solutions indicate that it is probably cellulosic in nature.

†The angle which the strands made with the axis of the fiber were measured at the center of the fiber by means of a rotating stage marked in degrees.

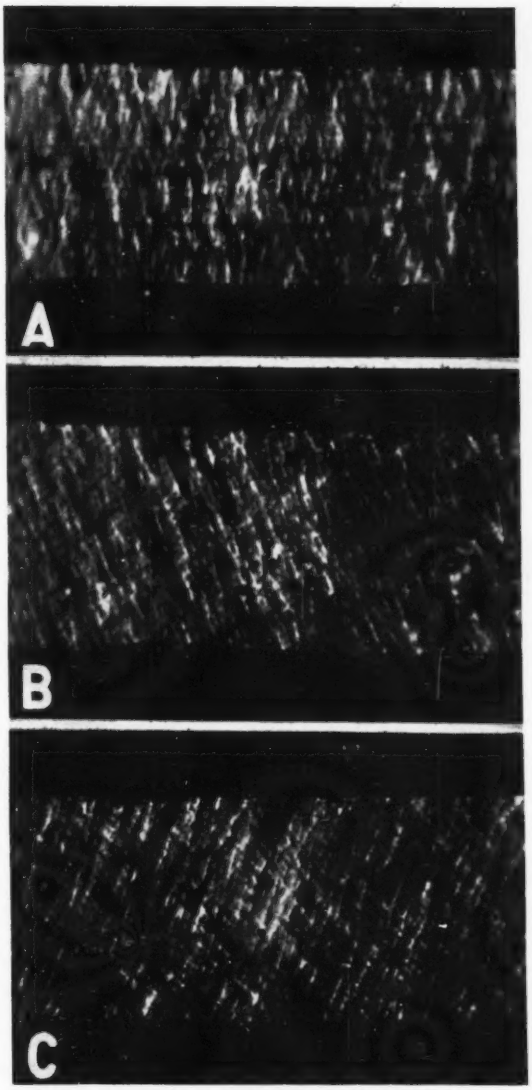

Figure 1. Raw 15-day cotton fiber stained with Congo red and photographed between crossed nicols.
A. Fiber at 45° with respect to planes of the nicols, showing criss-crossing strands of cellulose in the primary wall.
B. Same fiber placed at about 15° to the plane of light passing through the polarizer, showing one system of strands which predominate in this position.
C. Same as B, with fiber placed at about 15° to the plane of light passing through the analyzer, and showing the other set of cellulose strands.
Magnification X 890.

(compare Fig. 1, A with Fig 2, A) and showed greater birefringence in the older fibers. The greater birefringence of the older fibers is not readily apparent from the photographs as they were taken primarily to show the netlike structure. Measurements also indicated that the angle which the cellulose strands made with the fiber axis was greater at the tip than at the base. These differences were especially noticeable in 15-day fibers where the growing cell had nearly attained its maximum length.

The above observations were confirmed by the examination of single walls obtained by cutting longitudinal

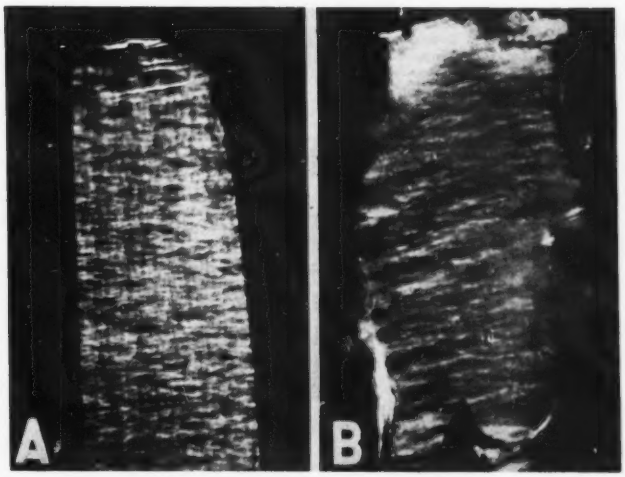

Figure 2. Raw fibers stained with Congo red and photographed between crossed nicols.
A. 3-day fiber at 45° with respect to the planes of the nicols, showing strands of cellulose in the primary wall.
B. Single wall of a 15-day fiber, showing stands of cellulose in the primary wall. Fiber placed at 45° angle with respect to the planes of the nicols.
Magnification X 890.

sections of the fibers with the aid of a freezing microtome. Staining reactions and birefringence measurements gave essentially the same results as those obtained with intact fibers (Fig. 2, B).

After the initiation of secondary thickening, the predominantly transverse orientation (with respect to the fiber axis) of the cellulose in the primary wall was masked, after a few days, by the more nearly parallel orientation of the cellulose in the secondary wall. This change was evident upon examination of the fibers with crossed nicols and a selenite plate, as well as by observation with ordinary light, and is in agreement with the results of the X-ray work of Berkley[18].

2. Single Fibers in Cuprammonium Reagent

The bulk of the cellulose of a cotton fiber is in the secondary wall. For this reason the attention of most investigators has been directed mainly to this part of the fiber.

In a previous investigation[19] it was found that the cellulose dissolved during the treatment of cotton with cuprammonium hydroxide solutions, leaving residues which varied in amount and in structure, depending upon the extent of purification of the fibers. When *raw* and *dewaxed* mature fibers were placed on microscope slides and then treated with cuprammonium reagent, the fibers immediately began to swell and twist, often forming balloon-like structures (Fig. 3, A). The residue which remained after dissolution of the cellulose consisted principally of fragments (Fig. 3, B) of the primary wall and, to a lesser extent, of material from the lumen. These residues were isotropic, contained pectic substance[12], and stained deeply with ruthenium red. They were often clumped into accordion-like structures which could be stretched with the needles of a micromanipulator to form continuous tubes corresponding to the condition in the intact fibers. These

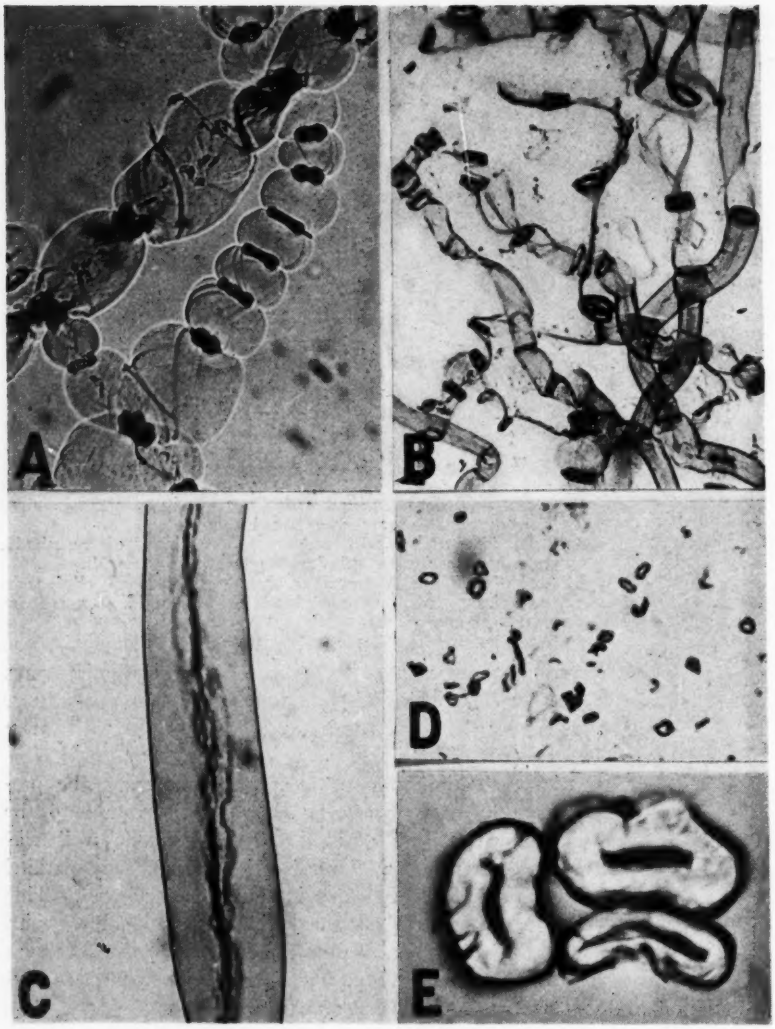

Figure 3. Raw cotton fibers in cuprammonium hydroxide solution.

A. Mature fibers swollen to form balloons.
Magnification X 120.

B. Residue which remains after the cellulose of raw mature fibers has dissolved in the reagent.
Magnification X 120.

C. Typical residue of a 22-day raw fiber after treatment with cuprammonium reagent.
Magnification X 500.

D. Residue which remains after treating cross-sections of mature raw fibers with cuprammonium reagent.
Magnification X 120.

E. Raw cross-sections of mature cotton fibers swollen slightly in dilute cuprammonium hydroxide solution, showing deeply stained material in the lumen and at the periphery of the fibers.
Magnification X 1220
All the fibers were stained with ruthenium red.

tubes, which appeared to be soft and pliable, were readily torn by this treatment. *Depectinized* fibers dissolved in cuprammonium reagent, leaving only a negligible amount of isotropic residue which exhibited no definite cell structure.

When immature fibers in which only a small amount of secondary thickening had occurred were treated with cuprammonium reagent, relatively few visible changes took place. Few "balloons" were formed and therefore the primary wall was left practically intact. The mild reaction of young fibers in cuprammonium hydroxide was in sharp contrast to the swelling, writhing, and twisting of mature fibers. Young fibers containing only small amounts of cellulose swelled little in the reagent, and the undissolved wax and pectic materials maintained the original tubular shape (Fig. 3, C) of the primary wall. By noting their behavior in cuprammonium hydroxide, it was thus possible to distinguish mature from immature fibers.

3. Cross-sections of Fibers in Cuprammonium Reagent

In order to study further the behavior of cotton fibers in cuprammonium reagent, cross sections of *raw, dewaxed,* and *depectinized* fibers were made. The usual procedure for making sections, whereby the fibers are embedded in paraffin, collodion, gelatin, or a similar material, could not be used as it is necessary to remove the embedding materials from the sections after they are cut, and the solvents used for this purpose also take out some of the waxes or pectic substance from the untreated cotton fiber. Accordingly, cross sections were made by simpler methods, which may not give sections as uniform as those obtained with embedded material, but have the advantage of leaving the fibers unaltered in their chemical composition.

By means of the device of Hardy[20], fibers were cut into sections about 10 μ thick without embedding. The sections were placed on microscope slides and then examined as cuprammoninum hydroxide solution was drawn under the coverglass. The sections of *raw fibers* swelled in the reagent, and in a short time the cellulose appeared to be dissolved, leaving a residue in the form of rings and other fragments of material (Fig. 3, D) which stained with ruthenium red. Most of the residue came from the

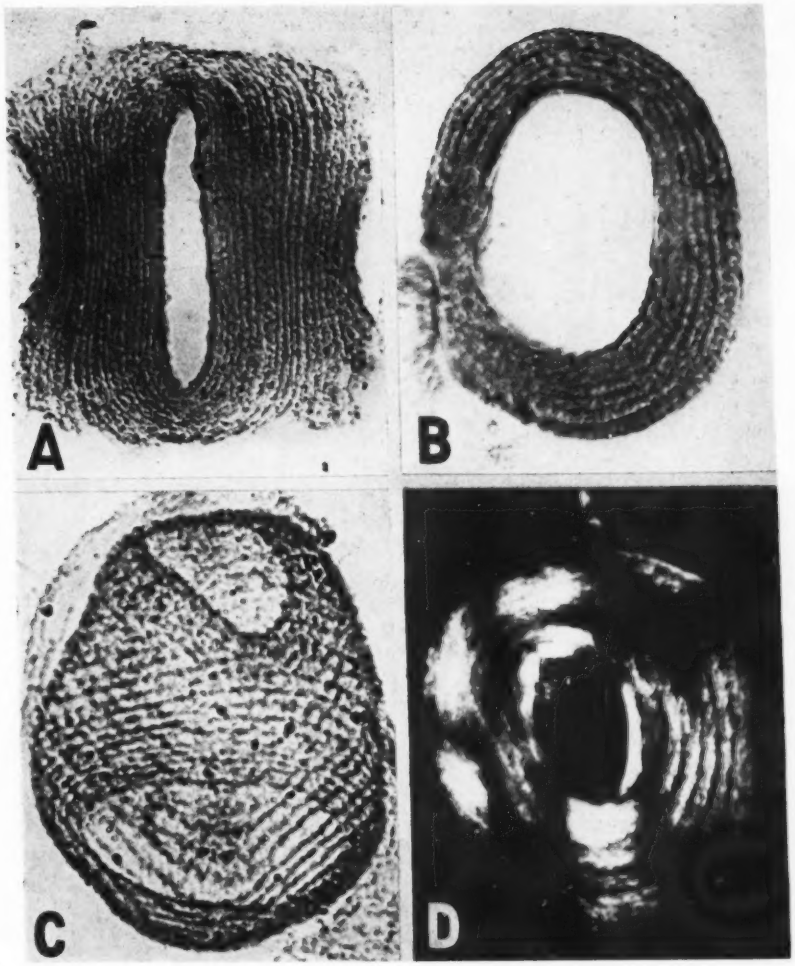

Figure 4. Cross-sections of the depectinized cotton fibers swollen in cuprammonium hydroxide solution to show lamellae.

A. Section of mature fiber showing lamellae.
Magnification X 420.

B. Section of immature (25-day) fiber showing lamellae.
Magnification X 945.

C. Section of mature fiber swollen to show lamellae, and partly inverted to produce a cone-shaped structure.
Magnification X 420.

D. Section of 26-day fiber showing lamellae.
Photographed between crossed nicols.
Magnification X 700.
All the fibers were stained with Congo red.

surface of the fiber, a lesser amount from the lumen. When this behavior was observed with crossed nicols, it was noted that the birefringence of the sections was lost as the cellulose dissolved, and that the residue was isotropic. When sections were swollen only slightly in dilute cuprammonium reagent and then placed in ruthenium red, deeply-stained red bands were discernible at the circumference and in the lumen (Fig. 3, E). Sections of *dewaxed fibers* behaved in essentially the same way as raw cotton. Dissolution of the cellulose took place rapidly, leaving an isotropic residue which stained with ruthenium red and was similar to that obtained from the raw fibers. When sections of *depectinized fibers* were treated with cuprammonium hydroxide they dissolved almost completely in the reagent.

Cuprammonium reagent dissolves the cellulose of single cotton fibers or of cross sections in a relatively short time. On the other hand, dilute solutions of the reagent swell the fibers but dissolution of the cellulose is greatly retarded. Swelling fibers in this way offers an excellent means of observing details of their structure. Cross sections about 10 μ thick were placed on microscope slides, and then treated with cuprammonium hydroxide solution which had been diluted four to six times with concentrated ammonium hydroxide. The sections swelled to many times their original diameter, thereby revealing a lamellate structure (Fig. 4A, and B). During the course of swelling the sections usually inverted so that the region originally at the surface of the fiber occupied the former position of the lumen. Where inversion was incomplete, cone-shaped structures were formed (Fig. 4, C). Inversion was observed in sections of fibers from which the wax and pectic substance had been removed, as well as in raw fibers. Very thin sections of mature fibers sometimes swelled without inverting. It should be pointed out, however, that a slight tear at the periphery, such as might easily occur in making sections only a few microns in thickness, would allow the sections to expand without inverting. Cross setions of immature fibers with only a small deposit of cellulose usually did not turn inside out. Apparently in immature fibers the lumen is sufficiently large to allow for expansion of the relatively small amount of cellulose. The regularity with which inversion accompanies the swelling of sections of mature fibers indiates that structural features of the fiber itself may be responsible for this phenomenon. Since inversion occurs

regularly, even in depectinized fibers, the insoluble wax and pectic substance in the primary wall cannot be primarily responsible for the observed behavior. It appears, therefore, that inversion may be due to a constricting influence, possibly of a layer or membrane which has not yet been identified, or what seems to be more probable, to a differential rate of swelling between the inner and outer layers of the cellulose of the secondary wall.

4. Lamellae and Growth Rings

Lamellae were not readily seen in untreated cross sections but were clearly visible in properly swollen material. When treated with cuprammonium reagent diluted four to six times with concentrated ammonium hydroxide, swelling of the cellulose took place in such a way as to reveal lamellae. Slight pressure on the cover glass helped to spread the swollen sections and thus render the lamellae more distinct, but this technique was not necessary for making these structures visible. When, for example, the cover glass was supported by bits of broken cover glass to prevent pressure on the sections, swelling took place as usual and lamellae were clearly discernible. Likewise, when the sections were swollen in a hanging drop preparation* lamellae were similarly observed.

On treating the swollen sections with Congo red, alternating lamellae appeared to be deeply and lightly stained with the dye (Fig. 4A, and B). Between crossed nicols these sections showed alternating layers of strong and of weakly birefringent materials, (Fig. 4, D).

The above-described techniques were applied to Missdel-7 and to Mexican Big Boll cottons. In both varieties the structure of the fibers was essentially the same. The average number of lamellae in a mature fiber was between 45 and 50. Individual lamellae varied in thickness from 0.1 to 0.2 μ†. The first lamella appeared to be deposited between the eighteenth and twentieth day after flowering, the number increasing thereafter as the fiber approached maturity. The increase in the number of lamellae with age can be seen by comparing Fig. 4, A with Fig. 4, B.

The lamellae, so clearly observed in swollen cross sections, can also be seen in longitudinal view[1] when the microscope is focused midway between the upper and lower surfaces of a swollen fiber. Fibers from which both wax and pectic substance were removed were preferable for these observations, as the purified fibers swelled more uniformly than raw fibers. When observed in this way the fibers showed striations** running parallel to the fiber axis and extending from the lumen to the outer surface (Fig. 5, A). The striations were readily discernible in unstained mounts, but the addition of Congo red rendered

Figure 5. Depectinized cotton fibers swollen in cuprammonium hydroxide solution to show striations.
A. 51-day fiber showing striations. Magnification X 500.
B. Mature fiber showing striations. Photographed between crossed nicols. Magnification X 420.
All the fibers were stained with Congo red.

the pattern more distinct. When examined with crossed nicols alternating stripes of strong and of weakly birefringent material were observed (Fig. 5, B). As the fiber matures, the thickness of the wall becomes greater and the number of striations is increased. The number of striations in Mexican Big Boll from 18 days to maturity was found to agree with the number of lamellae counted in cross sections.

According to Kerr[6], two lamellae, one compact and one porous, are deposited each day during the period of secondary wall deposition. These two lamellae (or two adjacent striations) together constitute a daily growth ring. Using "growth ring" in this sense, the relationship between these rings and the age of the fiber is shown graphically in Fig. 6. It is readily seen that there is a close correlation between the counts of lamellae and of striations. For the first 10 to 15 days after the initiation of secondary deposition, one growth ring was laid down per day. Thereafter, until maturity, additional growth rings were formed but the rate of one ring per day was apparently not maintained. However, closer examination of the data showed that the counts of lamellae and of striations varied considerably in fibers older than 35 days. This may mean that individual fibers continue to deposit one growth ring daily but that the average for the group is lowered because of the early maturation of some of the fibers. These results confirm the work of Balls[1] and Kerr[6]; they are not in agreement with the results of the investigations by Sakostchikoff and Korsheniovsky[5] and Barrows[9], who were unable to establish a consistent relationship between the number of lamellae and the age of the fibers.

*The sections were placed in a drop of dilute cuprammonium hydroxide solution on a cover glass, and the latter was inverted over a depression in a microscope slide.

†The width of the lamellae was obaitned by dividing the thickness of the wall of the unswollen fiber by the number of layers counted after swelling.

**In the present paper, the layers observed in cross-section are called lamellae, whereas the layers observed in longitudinal view are called striations. Both lamellae and striations refer, however, to the same structures.

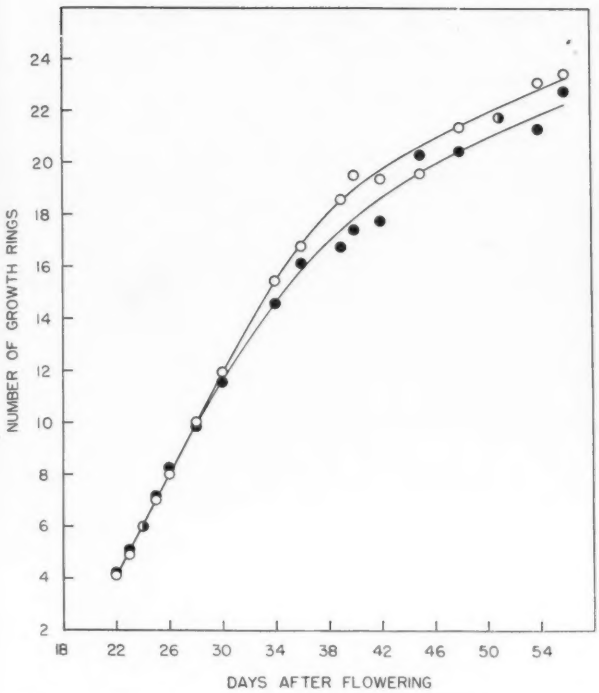

Figure 6. Growth rings in relation to the age of the fiber. Open circles represent growth rings estimated from the number of lamellae counted in fiber cross-sections (25 sections counted for each point of the curve). Solid circles represent growth rings estimated from the number of striations counted in longitudinal view (50 sections counted for each point of the curve).

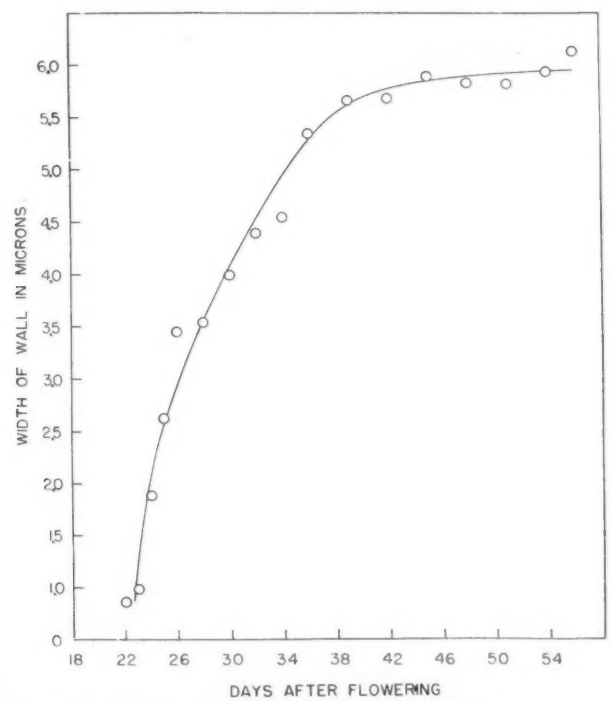

Figure 7. Increase in width of the wall with increase in age of the fiber.
Each point of the curve represents an average of 200 measurements.

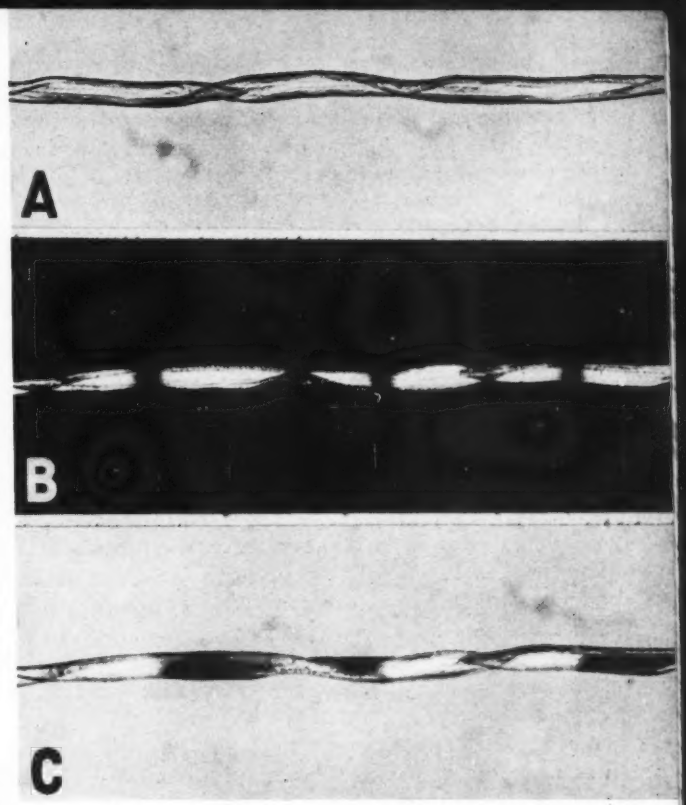

Figure 8. Raw mature fiber mounted in water and photographed under various lighting conditions.
A. Ordinary light, showing convolutions in the fiber.
B. Between crossed nicols, showing bands of extinction where the fibrillar orientation reverses.
C. Between crossed nicols and with selenite plate, showing the effect due to differences in color in regions adjacent to the extinction bands.
Magnification X 180.

Fig. 7 shows the increase in width of the secondary wall with increase in age of the cotton fiber. After about the first 15 days of secondary wall formation there is only a slight increase in thickness as the fibers continue to mature. This is consistent with a recent investigation[21] in which it was demonstrated that the percentage of cellulose in a series of cotton samples of different ages increased rapidly until about the 35th day after flowering, and that thereafter there was only a small further increase with age. A comparison of the curves of Figs. 6 and 7 suggests that the initial growth rings are wider than those laid down after the 35th day.

Lamellae, or striations, were also revealed when fibers were treated with reagents other than cuprammonium hydroxide. Trimethylbenzylammonium hydroxide had essentially the same effect as cuprammonium reagent. Combined treatment with sodium hydroxide and carbon disulfide, and treatment with phosphoric acid also revealed a lamellate structure in the fiber, but cuprammonium hydroxide and trimethylbenzylammonium hydroxide were preferable for this work.

5. Fibrillar Structure

The investigation of the structural details of the cotton fiber was continued with single fibers. These were mounted

in distilled water (Fig. 8, A), and then examined with crossed nicols. When the fibers were placed approximately parallel to the plane of vibration of light through one of the prisms, the high birefringence of the fiber was interrupted by dark extinction bands at irregular intervals along its axis (Fig. 8, B). The same phenomenon has previously been noted by Balls[2]. When a selenite plate was inserted between the nicols, contrasting colors, indicative of differences in orientation, appeared in regions adjacent to the extinction bands (Fig. 8, C). The number of convolutions or twists of the fiber which occurred in a region between two bands of extinction varied considerably, depending apparently on the length of the region. However, in a region which showed uniform optical properties the convolutions were always in the same direction.

The optical variations just described were also correlated with differences in structure observed in depectinized* fiber swollen in dilute cuprammonium hydroxide or in solutions of trimethylbenzylammonium hydroxide. For this experiment the cuprammonium reagent was diluted 3 to 4 times with concentrated ammonia and the trimethylbenzylammonium hydroxide was diluted with water to a concentration of 2.2 to 2.4 *N*. Upon swelling, the fibers clearly revealed a fibrillar structure. The bulk of a fiber was made up of innumerable fine fibrils oriented at an acute angle with respect to the axis of the fiber. The fibrils were enclosed by a winding† which appeared to be a little coarser than the fibrils themselves.

In fibers which had been swollen only slightly, it was observed that this outer winding was closely spaced and made a moderately steep spiral (Fig. 9, A and B). The winding, like the bulk of the fiber, stained with Congo red, zinc chloride-iodine, and iodine and sulfuric acid, and appeared to dissolve in cuprammonium reagent. It made either an "S" or a "Z" twist** around the fiber, reversal of direction taking place (Fig. 9, C) many times in a single fiber. Examination showed that both types of twist occur with about equal frequency. Invariably the orientation of the fibrils immediately beneath the outer winding was in the opposite direction. In other words, if the winding made an "S" twist, the fibrils immediately beneath made a "Z" twist. As far as could be determined, all of the fibrils under the winding at any one place appeared to run in the same direction.

It became apparent that reversals of direction of the cellulose fibrils and of the winding were responsible for the optical differences observed with crossed nicols, and that the band of extinction was the place at which the

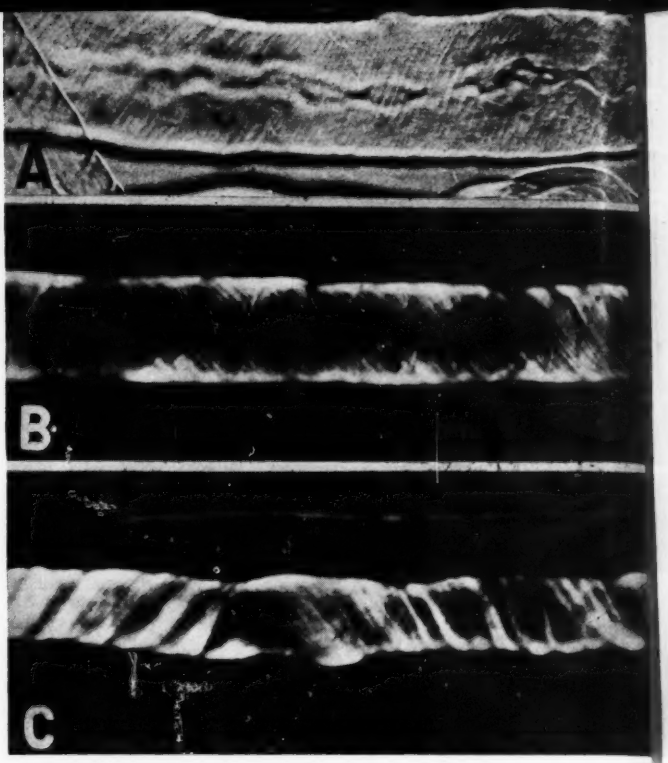

Figure 9. Depectinized fibers showing the winding.
A. Fiber swollen slightly in dilute cuprammonium hydroxide solution.
B. Fibers treated with zinc chloride-iodine and photographed between crossed nicols.
C. Fiber showing reversal, treated with zinc chloride-iodine and photographed between crossed nicols. Magnification X 420.

reversals occurred. The number of optical reversals occurring in a single fiber or fragment invariably was the same as the number of fibril reversals. Likewise, the relationship between the fibrillar orientation and the convolutions became clear. It was found that the direction of a convolution usually was the same as the spiral direction of the winding. That is to say, when the winding made an "S" twist around the axis, the convolutions in that region also showed an "S" twist.

The fibrillar structure of the secondary wall was studied to better advantage upon handling the fibers with microneedles. In some cases the outer winding was picked up by the needles and pulled away from the rest of the fiber, or the winding was pulled along the axis of the fiber in such a way as to form a clump. Needles were brought into the innumerable fine fibrils comprising the bulk of the cellulose of the secondary wall only by careful manipulation. The difficulty in picking up these fibrils appeared to be due to lateral cohesion of the fibrils themselves. After insertion of the needles, however, the fibrils could be separated from one another (Fig. 10, A and B) and otherwise subjected to micromanipulative methods.

6. Balloon Formation

Depectinized fibers were also examined in cuprammonium hydroxide solutions of various concentrations.

(Continued on page 75)

*Depectinized fibers were best suited for these experiments, since, after removal of the outer membrane of wax and pectic substance, irregular swelling along the axis could be minimized.

†Although the winding closely resembles the fibrils which make up the bulk of the fiber, to facilitate discussion it will be considered separately.

**According to A.S.T.M. Standards on Textile Materials[22] a yarn or cord has an S twist if, when held in a vertical position, the spiral conforms in slope to the central portion of the letter "S," and a "Z" twist if the spirals conform to the central portion of the letter "Z." In the present paper the same terminology will be applied to fibrils.

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FEBRUARY 3, 1941

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CALENDAR OF COMING EVENTS

Final lecture in series, delivered by Dr. Malcolm Dole, and sponsored by Midwest Section will be given at the Chicago Lighting Institute, 20 North Wacker Drive, Chicago, Ill., February 7, 1941. Subject: "Structure of Synthetic Fibers."

Meeting, South Central Section, Read House, Chattanooga, Tenn., February 8, 1941.

Meeting, New York Section, Swiss Chalet, Rochelle Park, N. J., February 28, 1941. Motion picture "Color Symphony of Our Great West" will be presented by Werner von Bergen. Informal dance will follow.

Spring Meeting, Piedmont Section, George Vanderbilt Hotel, Asheville, North Carolina, April 12, 1941.

Annual Meeting and Convention, Carolina Hotel, Pinehurst, N. C., Oct. 31, Nov. 1, 1941.

2nd PRIZE
Winner of the Intersectional Contest

Some Observations on the Tendering of VAT and NAPHTHOL DYED ARMY DUCK on Total Exposure to Weathering*

FOR several years the increasing use of vat dyed heavy fabrics (principally army ducks) for the fabrication of various articles for outdoor use, such as beach umbrellas, gliders, swings, tents and chairs, has resulted in more or less serious consumer dissatisfaction due to abnormally rapid weakening of the fabric on comparatively short exposure to the weather.

The dyers and finishers of these fabrics have correctly attributed this abnormal tendering to the acceleration of destructive influences, principally sunlight, by the action of the vat dyestuffs, but considerable disagreement resulted as to the magnitude and extent of this effect. For some time it has been known that under certain conditions vat colors accelerated the destruction of the cotton fiber, and considerable published and unpublished work has been done on the problem, notably in England. In most cases, such weakening of the fiber has been blamed on the presence of certain specific colors, mostly yellows and oranges; but on the other hand, investigation of cases of tendering in fabrics in actual use seems to point to the possibility that any severe fading regardless of the color or colors involved results in a roughly corresponding tendering.

In order to learn something of the behavior of certain shades commonly used in the outdoor furniture trade, it was decided to expose a series of commercially dyed samples to complete weathering for a period of approximately two months under uniform conditions, and to determine what relation, if any, exists between degree of fading and degree of tendering. The fabric chosen was 30" 8.42 oz. army duck, bleached, mercerized, and vat dyed by the pigment-pad method in 13 typical shades ranging in depth from a tan to a royal blue and bordeaux, carrying from as little as 2 ozs./gallon to as much as 18 ozs./gallon of pigment in the pad liquor. No materials other than the vat pigment, except a penetrant, were added to the pad liquor, and the jig reduction bath was adjusted in the conventional way as to hydro-caustic ratio and amounts, also temperature, depending on the depth of shade and combination of colors. In all cases oxidation was accomplished with bichromate and acetic acid, and the fabric was soaped on the jig with a sulfonated alcohol.

To obtain a comparison of the behavior of similar shades dyed with vat and naphthol colors, three naphthol combinations were included, a bordeaux, a red, and a yellow, all of which were padded then coupled on the jig. Strength of the padding naphthol varied from 4½ ozs./gallon in the case of the bordeaux to 2 ozs./gallon for the canary yellow. After coupling, the shades were soaped on the jig with sulfonated alcohol and soda-ash in the case of the bordeaux and red, but with sulfonated alcohol only in the case of the yellow. To serve as a control, two pieces of the same fabric in the grey were also exposed with the dyed samples.

Exposure of the samples for a period of eight weeks was made by the Engineering Experiment Station of the Alabama Polytechnic Institute at Auburn, Ala., starting July 31st, and ending September 25, 1940. To support the dyed cloth, wooden frames were constructed consisting of a rack approximately 18 feet long by 30 inches wide, supported by one short leg 6 inches high and one long leg 21¼ inches high, thus giving an angle of 45 degrees to the frame. Construction was so arranged that each frame carried four open spaces approximately 50 inches long by 26 inches wide, with a slot about ½ inch wide between the vertical members running from top to bottom so the cloth could be passed thorugh this and carried to the back of the frame. Four such racks were used for the exposures.

From approximately 4 yards available in each shade, about 1 yard was retained as an original sample, and the remainder attached to the wooden frame in such a way that one-half of the piece was exposed directly to the weather day and night, facing south at an angle of 45 degrees, while the other half was doubled under the frame, which protected it from the direct impact of the sun's rays and rain but which allowed full circulation of air and admitted indirect light. Samples were attached to the frames by tacking to the face of the upright member at one end, drawing through the slot between the vertical supports at the opposite side of the open space and tacking again at the back of the original support, using slight tension. In this method, the warp of the fabric ran horizontally in the frame and the filling ran vertically.

The exposures were made on the roof of a one-story building, about 20 feet from the ground, with no nearby trees and no other buildings within 100 yards. As no industrial plant exists within 8 miles and the period of the exposure was in the summer, there was little or no possibility that industrial gases or products of the combustion

*Presented by Southeastern Section, Inter-sectional Contest, Annual Meeting, New York, N. Y., October 18, 1940. Also presented at meeting, Southeastern Section, December 7, 1940.

of coal could have affected the results. During the period of the test the weather at Auburn was abnormally clear and dry, scattered showers occurring on only three non-consecutive days, with a total precipitation for the entire period of less than 1 inch.

On completion of the exposures, breaking strength tests were made on a vertical Scott testing machine by the standard grab method after having been conditioned for 48 hours in an atmosphere of 70 degrees Fahrenheit and 65 per cent relative humidity. Ten breaks each, warpwise and fillingwise, were made on each sample, and the results averaged. In recording and summarizing the results of the tests, the figure used for each sample is a combined average of the warp and filling expressed as percentage loss in strength compared with the unexposed sample. Breaks were made in this way on the grey and dyed samples in two sets, one from the fully exposed top portion and one set from the bottom or underneath portion which was protected from the direct rays of the sun and the rain.

After the exposures were completed, samples of the faded and original fabrics were submitted to eight experienced persons for a visual determination of the percentage of color destruction, as facilities for colorimetric determination of color loss were not available. The figures used for percentage destruction of color are averages of the figures submitted by the eight observers.

Summarized results of the tests are shown in partially graphical and partially tabular form in the accompanying illustration, which lists the figures for the average of the grey cloth control samples, thirteen vat dyed and three naphtol shades. Opposite each heading which gives the shade name and color combination are two line-graphs based on a scale of 100, the top one of which represents the loss in strength on the fully exposed samples expressed as a percentage of the original strength, and the lower one of which shows percentage of color destruction determined as outlined above. On the right is a table giving the weakening effect found in that portion of each sample on the under layer protected from direct rays of the sun, expressed as the average percentage loss in strength compared with the unexposed samples.

Shade	Colors	20% 40% 60% 80%	Loss Shielded
GREY FABRIC			31%
VAT ROYAL BLUE	BLUE BCS VIOLET 3B		50%
VAT BROWN	OLIVE T BROWN BRA		34%
VAT LEGION	BLUE BCS		64%
VAT SPRUCE	O GREEN BA JADE GREEN		57%
VAT LACQUER	BROWN AR ORANGE 4R RED RK		50%
VAT RUST	BROWN AR ORANGE 4R BROWN BRA		49%
VAT GREEN	JADE GREEN YELLOW 4G		69%
VAT BORDEAUX	RUBINE RD BROWN BRA		62%
VAT PURPLE	VIOLET 4RN		11.4%
VAT ORANGE	ORANGE RRT		50%
VAT TAN	BROWN AG BROWN AR YELLOW PGA		100%
VAT NILE	JADE GREEN YELLOW GC		68%
VAT YELLOW	YELLOW 4G		58%
NAPHTOL BORDEAUX	AS-3G BOR GP BASE		66%
NAPHTOL RED	AS-SW RED KB BASE		45%
NAPHTOL YELLOW	AS-G SCAR SALT 3G		31%

Under the conditions of this investigation, the normal weakening effect, exclusive of dyestuff effect, on the totally exposed portion of the samples seems to be approximately 20 per cent as represented by the average weakening of the control samples of grey cloth. In the case of the fully exposed dyed samples, the tendering ranged from approximately that of the control samples in the case of the slightly faded shades to about 50 per cent for the badly faded ones, or expressed in another way, the weakening effect on the badly faded samples was 2.6 times that of the slightly faded samples. The average degree of weakening obtained in the dyed samples in the investigation is less than that obtained in a previous and smaller series of exposures conducted under about the same conditions, although there was little difference in the tendering of the control samples of grey fabric in the two series. The principal difference in the conditions of the two series is the fact that the first set of exposures was made during a period when frequent rains occurred, while the present set was made during abnormally dry weather as explained above. This suggests the possibility that alternate wetting and drying of the fabrics has an accelerating action on the fading of the dyed samples, however, it should be pointed out that the first exposures were made on the roof of a finishing plant where there was opportunity for contact with both products of combustion and industrial gases.

From the summary of the results shown graphically, it is apparent that there is some relation between degree of color destruction and amount of tendering, also that tendering increases with increased fading, within limits, the degree of weakening being roughly proportional to the color destruction. The least faded samples show percentages of tendering comparable to that of the control samples, increasing with greater fading to a figure 2.6 times that of the control samples where the color destruction is of the magnitude of 85-95 per cent. In the case of the sample identified as Legion Blue, dyed with Blue BCS, there was a very distinct change in shade rather than actual loss in total depth of color which, in the case of a few of the men who rated the faded samples, was penalized as color destruction, but which was ignored by most: For this reason, it is probable that the average figure used to represent color destruction for this sample is too low. The samples identified as Tan and Nile were very much lighter

in depth than the balance of the samples, and the high percentage of fading in these cases is at least partially due to the lack in depth of the original shade.

While it is true that the three vat dyed samples showing the highest degree of color destruction and also the greatest weakening effect contain yellow, varying from 100 per cent to about 4 per cent of the formula, the tendering is not nearly as great in proportion to the fading in these samples as in the others containing no yellow, the greater weakening of these samples seeming to be due to the greater degree of color destruction rather than to any specific effect of the yellow dyestuff.

All of the naphthol dyed shades showed very high color destruction ranging from 90 to 95 per cent, but the comparative tendering produced was materially less than the vat dyed shades showing comparable fading, ranging from slightly more than that of the control samples in the case of the bordeaux, to 50 per cent greater than that of the control samples in the case of the yellow. This point is well recognized in commercial work where naphthol combinations are always used instead of vats when the vat shades are not materially faster, thus avoiding some of the worst cases of tendering.

Loss in strength of the portion of the samples on the under side protected from the direct rays of the sun and also rain, was of a low order ranging from 1.5 per cent to 11.4 per cent, the control samples giving an average figure of 3.1 per cent, the vat dyed samples 6.4 per cent, and the naphthol dyed 3.7 per cent. Other than indicating that apparently even here the vat dyes have some effect in catalyzing tendering, these figures are not particularly significant except for offering a comparison between partial and complete exposure of the samples.

While the scope of this investigation was not as broad as might be desired, the results indicate that the problem of excessive tendering of vat dyed fabrics under practical conditions of use is a real one, that fading in excess of 15-20 per cent produces weakening above that of undyed material, and that in general tendering is proportional to fading, regardless of the colors used in dyeing the fabric.

A great deal more work of a fundamental nature should be done on this problem, as it is interesting technically and serious from a practical standpoint.

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Variables Encountered in FADE-OMETER TESTING*

3rd PRIZE
Winner of the Intersectional Contest

THIS report is concerned principally with only one condition which could conceivably influence fading in some respect. The work was undertaken to learn how exposures attached to cardboard compared with exposures made in the metal frames furnished with the Fade-Ometer. The experiments illustrate that the results are not identical in all respects, however, the differences are principally in respect to the time required to effect identical degrees of fading. Fading proceeds more rapidly when the samples are attached to cardboard than it does when they are exposed in the frames. Contrary to expectation, there is only a very small difference in the rate of fading between exposures made in closed and in open Fade-Ometer frames. In closed frames, the rate of fading is still appreciably slower than when the samples are attached to cardboard. The conclusion that may be drawn from these experiments is that the usefulness of the Fade-Ometer is not restricted to exposures made in the frames furnished with it. This is important because it increases its capacity in respect to the number of samples that can be exposed simultaneously. Eighteen metal frames to hold the samples during exposure are standard Fade-Ometer equipment. Each frame is formed to hold two samples, measuring 2 x 1½ inches, limiting the capacity to thirty-six samples. For many purposes, smaller size samples are equally useful and the frames are not ideal when it is desired to make large numbers of exposures together and retain them for reference purposes.

This led to the practice of exposing the samples attached to cardboard. Obviously, the number of samples that can be exposed together or simultaneously is only limited by their size and the space around the arc within which the light is uniformly or equally destructively effective. One dimension of this space is fixed by the circumference of the frame from which the samples are suspended. The other, on a horizontal line above and below the center of the arc may be assumed as fixed by the cut out sections of the frames at the points farthest or most distant from their

*Presented by Philadelphia Section, Inter-sectional Contest, Annual Meeting, New York, N. Y., October 18, 1940.

centers. That the uniformity of destructive effectiveness of the arc extends at least one inch beyond those points is illustrated by eight exposures in which cardboard, cut to the measurements of the Fade-Ometer frames, was entirely covered with colored cloth and exposed. These exposures demonstrate that the established custom of the use of three inches above and below the center of the frames is sound practice and justified.

If, as has become customary, the samples for exposure are cut one inch in height, six can be exposed in a frame, thus increasing the number that can be exposed together to 108. If the width of the cardboard to which the samples are attached is made three inches and an inch strip of cardboard fastened over the center of the samples being exposed, two different time period exposures can be made simultaneously. The portion to the left may be covered when it shows a definite change and the exposure of the portion to the right continued as desired.

Grey colored, as well as black and white, cardboard is in use. Samples of the nineteen dyes used for the present experiments were exposed attached to grey, to white, to yellow, to red and to blue colored cardboard. The results indicate that the color of the cardboard has some influence on fading, however, principally on the time required to secure a similar degree of color change or destruction. The influence of the different colored cards varies with the individual dyes, however, it is not sufficient in any instance to impair the usefulness of the Fade-Ometer. The greatest differences are in the exposures attached to the yellow, red and blue colored cards. Because they are seldom used, the differences between them are of greater academic than practical interest and the practical usefulness of this report will be served by consideration of the differences between exposures on grey and on white cards only. These differences are small and negligible for practical purposes. All six wool dyeings show a trace more fading on the white than on the grey as do three of the silk and one of the cotton; whereas one silk and five cotton dyeings show a trace more fading on the grey than on the white cards. There is no definitely observable differences between the exposures of the remaining four dyes.

Because it is convenient to utilize metal frames as a means of support for the cardboards during their use for exposures, another set of samples, attached to the different colored cards and then attached to bright sheet tin, was included. A majority of the nineteen samples show an easily observable greater degree of fading when the cardboard is attached to the tin. There are some exceptions, principally among the silk samples and principally between the exposures on the grey and white cards. However, with one exception, all of these differences are of a minor degree and too small to be of particular practical interest. The exception is the wool sample colored with Hematine. The exposure on the grey card attached to the tin has caused practical color destruction and a much greater degree of color destruction than has been effected on any of the other nine exposures of this sample.

Naturally, to be comparative, all of the different exposures of each identical colored sample so far commented upon were made for identical time periods and together. This time period is not identical for all of the samples. As an illustration: the cotton colored with the Thioindigo Vat dye scarlet was exposed for 39 hours and the cotton colored with the Anthraquinone Vat dye violet for 76 hours, etc.

As a means for comparison, a set of exposures, in which the samples were attached to the different colored cards, was made in natural light. These were not made in accordance with our Light Fastness Committee's recommendations, principally because too much cloudy and rainy weather would have prevented their completion within the time available. They were, therefore, exposed under glass between 9 A.M. and 5 P.M. and regardless of whether the sun was or was not visible. These natural light exposures are not identical in their degree of color change or destruction with the Fade-Ometer exposure. This was not considered necessary because they were prepared principally as the means to establish whether or not the quality of the changes in the Fade-Ometer exposure was of a general similar character.

As previously stated, the degree of change in the Fade-Ometer frames was less than when attached to the cards. As a means to measure the differences in a describable form, another set, in both open and closed frames was made for the time required to effect a degree of change like that on the cardboard exposures. This was not satisfactorily accomplished in all instances, however, the figures are included as Tables 1A—1B and 1C to illustrate that the increased time required is not uniform, however, it is consistently appreciably greater for silk and wool than for cotton.

The differences described naturally arouse speculation in respect to probable causes. Experience and available information immediately suggest variation in light intensity, in temperature and in humidity. Measurements of these were taken at four hour intervals and at different points during the time the exposures were being made. Only in the temperature recordings are the differences sufficient in degree to merit consideration as a possible cause. An average of the temperature recordings are described in Tables 2A and 2B. The figures in the column "Surface" are with the mercury bulb touching the surface of the cloth exposed toward the light. The figures in the column "Back" are with the thermometer inserted behind the cloth, between the cloth and cardboard and with the mercury bulb touching both. That temperature variation is an influence is indicated by the much lower temperatures at the back of the samples in the open Fade-Ometer frames and it is in this condition that fading proceeds most slowly. That temeprature variation is not the only influence is clearly indicated by the differences in the temperatures behind the cloths in the open and closed Fade-Ometer frames. In the closed

TABLE 1A

Fiber	Dye		Fadeometer Cards Hours	Fadeometer Frames Hours	Percentage Increase
Cotton	Cotton Yellow CH	CI 365	26		
Cotton	Sulfogene Brown CO Conc.		19	20-21	5-10
Cotton	Vat Scarlet G	CI 1228	39	50?	25-30
Cotton	Vat Violet RRD	CI 1104	76	90-95	20-25
Cotton	Methylene Blue BX	CI 922	19	24-26	25-30
Cotton	Diazo Indigo Blue 4GL Extra		59	64-66	8-10
Cotton	Sulfur Indigo Blue G Conc.		19	23-24	20-25
Cotton	Cotton Fast Green GL		39	45-48	15-25

TABLE 1B

Silk	Vat Orange R	CI 1217			
Silk	Cotton Violet N	CI 394	28	45-48	60-70
Silk	Anthraquinone Blue AB	CI 1075	35	52-55	50-60
Silk	Wool Green S	CI 737	21	32-34	55-65
Silk	Cotton Black EBN	CI 581	50	75-80	50-60

TABLE 1C

Wool	Metanil Yellow Conc.	CI 138	34	46-48	35-40
Wool	Wool Scarlet	CI 79	34	48-50	40-45
Wool	Wool Violet 4BSN	CI 53	34	46-48	35-40
Wool	Pontachrome Blue ECR		34	46-48	35-40
Wool	Serichrome Green B		58	88-90	50-55
Wool	Hematine Crystals		177	More than 200	More than 20

TABLE 2A

	Cotton Temperature Fahrenheit		Silk Temperature Fahrenheit		Wool Temperature Fahrenheit	
Cardboard	Surface	Back	Surface	Back	Surface	Back
White	108	138	135	150	122	133
Grey	112	153	135	150	124	144
Yellow	116	144	138	147	115	142
Red	120	140	140	145	126	142
Blue	125	153	143	158	124	136
Fadeometer Frame						
OPEN	134	106	135	105	129	106

TABLE 2B

Fastened to tin. Cardboard						
White	117	147	135	150	108	130
Grey	115	170	127	150	114	147
Yellow	133	159	128	158	116	158
Red	120	172	132	145	108	131
Blue	123	177	122	146	104	142
Fadeometer Frame						
CLOSED	132	135	143	150	140	142

Mean air temperature at point of exposures—104
Mean relative humidity at point of exposures—50%
Approximate light intensity at point of exposures, in foot candles 5,550

frames, the temperature is higher by 30° for cotton, 45° for silk and 36° for wool, yet the difference in the rate of fading is trivial in comparison. Another influence may be that the metal, being an efficient conductor of heat, dissipates its destructive energy into the surrounding air, whereas the cardboard absorbs and retains the heat and thus aids it to exert its destructive influence on the colors.

That the fibers have an influence is indicated by the figures in Tables 2A and 2B. In the columns headed "Back" the figures in A illustrate that with one exception, the silk temperatures are higher than both the cotton and wool temperatures, whereas in B, the silk temperatures are generally lower than for cotton. Regardless of the fact that the temperatures may not be sufficiently consistent to permit of reliable conclusions in respect to causes, the exposures illustrate in every instance without exception, that the Fade-Ometer is equally reliably useful, regardless of whether the samples are exposed in the frames or attached to cardboard and whether the frames are open or closed and whether the cardboard is white or grey. The experiments that led to this report were made principally and specifically to obtain that information. The experiments included only nineteen dyes and it is possible that with a very much greater number some exceptions may be found. These nineteen dyes were selected because they are the choice of our Light Fastness Tests Committee for their experiments when the number used must of necessity be limited.

TENTH ANNUAL MEETING, INTER-SOCIETY COLOR COUNCIL, WASHINGTON, D. C.

Tentative Program

THE meeting will be held on March 4 and 5, 1941. The technical session will be co-sponsored by the American Society for Testing Materials and will be held on March 5 during their Eastern Regional Meeting.

Delegates and members of the Council are urged to be present. Members of all member bodies, and any others interested in color, are invited to attend the sessions. The program will be announced more completely, both in the program of the A.S.T.M. meeting, and in a program of the I.S.C.C. available by request from the secretary (Box 155, Benjamin Franklin Station, Washington, D. C.) after February 1st.

Tuesday, March 4, 1941

March 4

9:30 A.M.—Discussion Session: Forrest Lee Dimmick, Chairman
At American Pharmaceutical Association Headquarters, 2215 Constitution Avenue.

2:00 P.M.—Annual Business Session: Deane B. Judd, Chairman
Reports of committees, and of chairmen of delegations from member bodies. (Reports should be in writing so that they may be included in the report of the meeting.)
At American Pharmaceutical Association Headquarters, 2215 Constitution Avenue.

6:30 P.M.—Informal Dinner for Delegates and Members

Wednesday, March 5, 1941

March 5

2:00 P.M.—JOINT ASTM-ISCC TECHNICAL SESSION: *Color—Its Specification and Use in Evaluating the Appearance of Materials*: M. Rea Paul, Chairman

This meeting will be held at the Mayflower Hotel, which is to be ASTM Headquarters

Introduction to Color—Deane B. Judd

Color of Transparent Materials—Francis Scofield

Hiding Power and Opacity—R. H. Sawyer

Color Standards for Opaque Materials—I. H. Godlove

The Spectrophotometer in the Determination of the Color of Materials—A. E. Parker

Photoelectric Colorimetry—Richard S. Hunter

8:00 P.M.—POPULAR SESSION: *Parade of Color*: Wm. D. Appel, Chairman

ASTM members will join the ISCC for this session. The meeting is to be held in the auditorium of the Potomac Electric Power Company, 10th and E Streets, N.W., the usual meeting place of the Washington-Baltimore branch of the Illuminating Engineering Society, who, with the Washington Colorists, are also joining the ISCC for this session.

Trends in Color Photography—an indispensable tool of the scientist and technician. Earl A. Trager, manager of Washington branch of Bell & Howell Company, formerly Chief Naturalist, National Park Service.

Paint Styling Demonstration will reveal interesting ways of creating color illusions on building interiors and exteriors. National Paint, Varnish & Lacquer Association, by prominent members of their Council on Paint Styling which keeps its finger on the color pulse of the Nation.

Exploring the Magic World of Color — a spectacular and thrilling presentation by the "World's Greatest Color Magician." Herbert Thompson Strong, color consultant, Museum of Science and Industry, New York City.

UNEMPLOYMENT REGISTER

Members of this association, who are without employment, should forward to the secretary a statement as to their qualifications and experience. This information will subsequently appear on these pages with an identifying key number. Employers are also requested to file with the American Dyestuff Reporter any vacancies which may occur in their business.—H. C. Chapin, Secretary, Lowell Textile Institute, Lowell, Mass.

NOTICE TO EMPLOYERS

● ***Complete personal histories and employment records of the following applicants are on file at the office of the American Dyestuff Reporter.*** ●

Key: A—Laboratory and research; B—Dyeing or printing; C—Finishing; D—Sales; E—Instruction; F—Executive.

NOTE: PERSONS WHO HAVE OBTAINED EMPLOYMENT SHOULD NOTIFY THE SECRETARY OR THE AMERICAN DYESTUFF REPORTER AT ONCE.

A-1

Education—Graduate textile chemistry and dyeing course, Lowell Textile Institute, 1932. Special course in colloid chemistry at M.I.T.

Experience—Library work in spare time while attending school; five years as assistant chemist with knitting mill, duties consisting of testing and grading silk, testing of oils, soaps, dyes, finishes and other chemicals, making up specifications for various lines of hosiery and checking finished product, keeping a check on production costs, control of waste and irregulars, checking competing products and carrying on research to improve product and reduce costs. Woman; age 30; references.

A-B-8

Education—Graduate Chemist.

Experience—Print superintendent, colorist; eleven years' experience in all types of fabrics, specializing on rayon; 8 years' dyestuff laboratory and demonstrating. Excellent references; age 37; married.

A-B-9

Education—Textile School Graduate.

Experience—Executive and sales type of textile chemist and colorist desires position in sales, contact, promotional or supervisory work. Factory, laboratory, office and purchasing experience. Good correspondent. Good personality. Accustomed to assuming responsibility and exercising initiative. 21 years' experience in the textile, chemical and dye industries. Opportunity most important. Age 43; American; married.

A-B-10

Education—1 year of textile chemistry, day course, Philadelphia Textile School; also business course.

Experience—3 years as apprentice in weaving mill in Germany, office and stock room, general clerical work, practice in all departments of cotton manufacture, dyeing, bleaching and finishing of cotton-rayon mixtures, piece and package processing; several mos. in laboratory of German dyestuff manufacturer, dyestuffs and assistants and their application, vat and naphthol dyeing.

Age 20; will go anywhere in U. S.

A-B-11

Education: Graduate chemist. Correspond and converse German, some French.

Experience: 3 years dyer; 4 years dyestuff testing, trouble-shooting, purchasing; 4 years demonstrating, consulting, and supervising for large dyestuff manufacturer. Thoroughly experienced on rayon, cotton, silk, acetates, printing, vats. Fullest references as to character and ability. Seeks position as technician, consultant, or superintendent with reliable dyestuff sales organization or dyehouse. Age 33, married.

A-B-12

Education—Philadelphia Textile School (Evening), Chemistry and Dyeing, Quantitative and Qualitative Analysis.

Experience—Two years in yarn office, making wool stock blends. Last 6 years in dyehouse, 4 years as kettle hand, 2 years in piece dye work. Worked on yarn, raw stock and piece goods; has been dyer on union piece goods, cotton, rayon and wool, leaving wool white; also worked on all wool fabrics and woolen cross dyes; also considerable laboratory experience doing laboratory dyeings and extraction work. Seeks position as dyer or laboratory technician. Age 30; married; references.

A-B-13

Education—B.S., Chemical Engineering, Oregon State College, 1926.

Experience—First experience in dry cleaning plant; few months as sampling and control chemist with potash and chemical company; two years in dry cleaning plant, all phases of work; few months on routine and special analyses, plant problems, special studies and research for gas and electric company; 10 years teaching experience on textile chemistry, dyeing and textile testing covering all general and special courses in this field; consultant work with various mills. Seeks position in textile chemistry or dyeing.

Age 37; married; will go anywhere; references.

A-B-14

Education—Graduate of New Bedford Textile School, chemistry and dyeing course.

Experience—Two years in dyeing filament rayon skeins; seven years general laboratory work in large print works; four years overseer of package dyeing of cotton and spun rayon with all types of colors. Plant liquidating; must find other employment

Age 34; married; references.

A-B-15

Education—Graduate chemistry, dyeing and finishing course, New Bedford Textile School, 1940.

Experience—None. Seeks position in dyeing or finishing departments or in testing (chemical, physical, microscopical).

Age 27; single; references.

A-B-16

Education—Graduate, 1932, 3 year evening course in chemistry and dyeing, Philadelphia Textile Schooi.

Experience—Chemist and colorist, 14 years, matching shades on all types of materials with most classes of colors. Also checking and testing dyes, finishes, soaps, oils, and making special color cards and samples.

Age 31; married, references.

A-B-C-4

Education—Educated abroad.

Experience—Twenty years experience in the textile field as bleacher, dyer, finisher and chemist. 16 years in charge of dyestuff laboratory of large dyeing plant, 4 years as chief chemist with large bleachery. Has tested dyestuffs, and chemicals used in the textile field and has manufactured soaps and textile specialties. Has handled all textile fibers; bleaching, printing, dyeing and finishing same. Has done pigment and lacquer printing, waterproofing and fireproofing. Reason for leaving last position was due to business conditions. Age 41; married.

A-B-C-9

Education—Lowell Textile Institute; chemistry, dyeing and textile finishing.

Experience—Twelve years head dyer in hosiery mills. Dyeing all types of fibers and in combination. Knowledge of all dye applications. Matching and formula making. Charge of every department in a hosiery mill except fixing machinery. Has done jigg work on cottons and rayons. Desires position in hosiery, or in any field. Would like to work as an assistant to head dyer in a woolen or ravon mill. Age 42; married. Will go anywhere in the United States.

A-B-C-10

Education—Graduate New Bedford Textile School, 1940.

Seeks position connected with chemistry, dyeing or finishing.

A-B-C-D-1

Education—Lowell Textile Institute, Bachelor of Textile Chemistry; Lowell Textile Institute (Evenings), 2 years D. C. Electricity; 2 years A. C. Electricity.

Experience—Six years as chemist and assistant dyer with a large organization. Specialized in dyeing, finishing, bleaching and drying of woolens, worsteds, cottons, rayons and unions in the piece. Some sales experience. Desires position as chemist, dyer, finisher, bleacher or sales. Age 30; American citizen; Married.

A-B-D-2

Education—Evening courses, chemistry and dyeing, Philadelphia Textile School.

Experience—Eighteen years varied experience as dyer and chemist. Dyeing experience on cotton, wool, shoddy, raw stock, union piece goods, mohair, rayons and alpacca.

Age 37; married; references.

A-B-C-E-1

Education—3 years Chemical Engineer major in college; honor graduate Philadelphia Textile School, chemistry and dyeing course.

Experience—Ten years experience as chemist, colorist, technical director in bleaching, dyeing and finishing of cottons and rayons. Also one year's similar experience in South America. Instructor of textiles and textile chemistry in state vocational school, 2 years. Married; age 32; references; will go anywhere.

A-B-C-F-2

Education—Graduate, Lowell Textile Institute, 1908.

Experience—Over 30 years experience as chemist, color mixer and matcher, foreman printer, foreman dyer on all types of fibers and colors, and finisher. Experience installing complete dyeing and finishing departments. Experience as manager of dyeing and finishing companies. Experience in New York market: interviews with converters, obtaining orders, new customers, settling claims, etc.

Age 51; married, will go anywhere; references.

A-B-D-1

Education—Special courses in general chemistry.

Experience—Twenty-nine years' experience in application and standardization laboratories of various dyestuff manufacturers. Well versed in the application of dyestuffs to different textile fibers, i.e., wool, cotton, rayon, silk, acetate rayon and unions, using direct, acid, diazo, sulfur, acetate rayon, chrome and after-treated direct dyestuffs. Six months' actual dye house experience on jigs, open boxes, padders, bleaching and mercerizing. Experience demonstrating sulfur and direct colors at various mills. Seeks position as textile colorist in application laboratory and demonstrator. Age 46; single; references.

B-6

Education—Graduate New Bedford Textile School; also post graduate work in advanced microscopy and rayon testing.

Experience—Five weeks in color shop of print works. Wants position in anything associated with textile chemistry, dyeing, finishing and testing. Single: age 21; references.

B-7

Education—Evening course in chemistry and dyeing at Philadelphia Textile School. Evening course in chemistry at Drexel Institute.

Experience—Started as second hand in dyeworks, then two years as head dyer on women's and children's hosiery. One year as head dyer with other dye works on all types of women's hosiery including Bemberg, rayon and cotton combinations.

Age 26; married; will go anywhere in U. S.; references.

B-8

Experience—20 years' experience with printing companies. Experience as colorist on basics, chromes, Indigosols, vats, rapid fasts, naphthols, Rapidogens and Aridyes. Seeks position as colorist and shader.

Age 49; married; references.

B-9

Education—Graduate of German textile school.

Experience—Twenty-seven years' experience abroad and in this country as chemist, colorist and dyer on cotton, rayon, wool, half-wool, half-silk and silk with various types of dyes and machines. Experience as trouble shooter.

Age 43; married; references.

B-C-1

Education—Two year night course in chemistry, Rhode Island School of Design.

Experience—Nineteen years' experience in printing and finishing plants, in practically every department. Has had direct charge of color shop and practical experience in both peroxide and chemic bleach. Also has had experience as assistant superintendent and superintendent of printing and finishing cotton and rayon piece goods and as company manager in finishing plant.

Age 38; married; references.

B-D-1

Education—General education in England. Chemistry and Dyeing Courses at Huddersfield Technical School.

Experience—Has been a superintendent of dyeing since 1911. Has had experience in worsted mills, hosiery mills and woolen mills. Congenial, sober and reliable. Married; references; age 53.

AMERICAN
DYESTUFF
REPORTER

A. P. HOWES
Publisher

LOUIS A. OLNEY, Sc.D.
Professor of Chemistry and Dyeing, Lowell Textile Institute
Directing Editor

NORMAN A. JOHNSON
Managing Editor

MYRON DREW REESER
Advertising Manager

Published biweekly by
HOWES PUBLISHING CO., INC.
440 Fourth Avenue, New York City

Subscription price: $5.00 per year. Canadian, $6.00; foreign, $6.00.

Vol. 30 February 3, 1941 No. 3

ORGANIZED RESEARCH NEEDS ORGANIZING

ONE of the advantages of a totalitarian form of government lies in the fact that all resources can be directed toward one end and done so quickly. One of the advantages lies in the fact that the individual freedom which is enjoyed of free enterprise means independent action and discoveries, knowledge gained from experiments, etc., which results in more total progress than would be the case if all the planning and directing was done by one small group with certain ends in view. Here in the United States, for example, we have our large and completely equipped industrial laboratories in which highly trained research workers are employed. We also have millions of individuals with little cellar, attic or kitchen laboratories and shops in which they are carrying on experiments and trying out ideas of their own. In this manner the greatest possible amount of information is gained. There is no idea so crazy but what somebody tries it out. A lot of work is being done with no great degree of preliminary planning and no immediate objective. This system, however, has resulted in the people in these United States gaining the reputation of being the most inventive and most resourceful people in the world. It is a country in which there has been great freedom in working on individual ideas.

Today, however, the world is at war. It is a war in which production plays a major part. It is also one in which the effectiveness of production depends a lot upon the research back of it. Here in this country we have more than 1,800 industrial research laboratories. They cover a great many different fields. Some 32 thousand trained research workers are employed in those laboratories. In addition we have all those individual experimenters of whom mention has been made. Such a force, well co-ordinated, should be able to accomplish wonders in the research back of war production and what they did might mean more for defense or winning a war than anything else could.

Research in dyes or in any branch of the textile industry might not at first sight have much apparent connection with other fields of research. As a matter of fact, however, research in all fields is closely related. Metallurgy might not seem to have any connection at all with research in surgery. Yet, it has provided the surgeon with better and better instruments and materials for operations and treatments. So, there is a real connection between the research in the fields of metals, machines, tools, etc., and the field of surgery.

One way to prepare for effective defense and one way to win a war is to discover some way of co-ordinating all research effort in the direction of more effective defense and offense. The newspapers report work is progressing in this country on experiments with a system which will make torpedoes and mines virtually harmless because a ship equipped with the system will be protected by the exploding of any torpedo or mine in the vicinity before they are close enough to do any damage. Reports are coming out of England that progress is being made in the direction of making air raids too costly for the raiders. This may be something entirely new which has been discovered through research or it may be merely propaganda.

Many an idea, however, requires the co-ordinated effort of researchers in many fields to bring the idea to the point where its application is practical. For example, a researcher in the combustion or fuel field might discover a fuel ideal for a rocket motor. A metallurgist might make that fuel practical by developing an alloy which would withstand the heat and any corrosive effect. In the radio or electrical field a method might be developed for directing an aerial torpedo, made of the new alloy and driven by the new fuel burned in the rocket motor toward a given plane. We now would have a practical aerial torpedo which when released would continue to travel in the direction of the plane toward which it was aimed and would keep on doing so until it reached that plane regardless of how the pilot of the plane maneuvered. At this point, however, it is discovered there is no known explosive which will serve satisfactorily in this new torpedo. As a result, it is of no practical value. However, if somebody in a chemical or dyestuffs research laboratory hits upon a suitable explosive, the effectiveness of air raids is reduced and may be made zero.

Such a case as this may be far fetched but it does illustrate what can be accomplished through co-ordination. A good many ideas which reach the war and the navy departments are not workable because they have not been

(Concluded on page 77)

The Network Structure of Cellulose

THERE has gradually grown out from the various views on the fine-structure of cellulose a conception which has become known as the network theory. It has reached more definite formulation largely from recent studies by O. Kratky and P. H. Hermans, based on experimental work, and is a compromise between the earlier idea of discrete individual micelles like bricks or building blocks, and ideas which have tended to oversimplify cellulose by attributing to it the properties of long chain molecules alone.

The concept of filament or long chain molecules made up of glucose residues joined by primary valences is familiar and must remain an essential part of any plausible theory.

Cellulose is now regarded as consisting of a network which includes regions of orderly crystalline structure, corresponding to the crystallites or micelles, connected together by individual cellulose chains or, more likely, by small groups of chains which pass through disordered regions which are between the more orderly groups.

An essential property of filament molecules is the ability of parts of them to rotate in the chains around primary valences. This property allows the cellulose chain molecule to conform better to other chains near it and to gather with other chains into a group, or to "agglomerate" (Kratky), without assuming any systematic form, into amorphous cellulose. Another essential property of filament molecules, as when a film is being formed from viscose solution, is the ability to crystallize. Owing to subsidiary valences (van der Waals forces) between them they tend to move to positions of equilibrium and to work themselves into a crystal lattice. Thus there are tendencies toward two kinds of structure, resulting in a combination of the two in proportions depending upon conditions at the time.

The chains which come together in the fundamental crystallite are parallel but they are not necessarily all of the same length. Hence the micelle has been defined as an ultra-microscopic mixed crystal of cellulose chains of different length, part of whose ends may project beyond the ends of the micelle and give a fringe effect. At times chains that are extra long will extend over into other crystallites so that the elongated micelles are thus bound into a net-like system of crystal regions connected by thinner strands consisting of long single chains or groups of chains. This network does not fill the system and part of the volume is occupied by disarranged, unoriented, or amorphus scraps of cellulose which have become agglomerated but have not become parts of the crystalline regions. In the amorphus portions chains are pointing in every direction like fibers in a piece of felt. There is, or is almost, another network, the amorphus cellulose, within the first, and within the whole structure there are still unfilled spaces or pores.

This general idea is not very different in effect from a six year old conception recently presented again as a basis for a discussion of direct dyeing (J. Soc. Dyers and Colourists *56*, 147). The working of the cellulose structure in textile processing can be illustrated as follows. When the cellulose is swollen in water the osmotic forces tend to cause the chains to move apart. In the crystalline areas this is prevented by crystal forces but in the intercrystalline regions the chain molecules can move apart until the swelling force is balanced by the elastic forces which tend to bring the structure back to its original size and shape.

Hysteresis in moisture absorption and desorption can be explained by a limited break down and a re-formation of these bonds only upon desorption to a lower value of the swelling.

While the cellulose is in the swollen form the chains between crystallites form an open network through which small molecules may pass easily. Large molecules penetrate with greater difficulty but capillary canals are large enough to admit direct dye molecules. These molecules cannot penetrate the crystallites because their constituent chains are too closely packed, hence dyes are absorbed on the smaller groups of molecular chains in the amorphous areas and no doubt on the outer surfaces of the larger groups or crystallites, particularly in the fringes. The reviewer suggests a possible difference also between native and hydrate or mercerized cellulose in the manner or extent to which dyes are attracted. With a possible allowance for this factor it is probable that the fraction of non-crystalline cellulose available for the fixation of dye molecules is a fairly definite quantity for each general variety of cellulose, one for cotton, one for ordinary viscose rayon, another for cuprammonium and so on.

There seems to be no real good source in English for the material discussed above. It is summarized, although very briefly, in Applied Chemistry Reports (Soc. Chem. Ind.), volume 24, page 160, for 1939, and was covered by Kratky in Silk and Rayon in 1939 in original articles with diagrams, of which the present notes are a partial explanation rather than an abstract.

Resins and Plastics

for the Modification of Textile Fabrics*

D. H. POWERS**

Recent years have seen the development of clear, colorless synthetic resins for textile fabric modification. These resins are applied as aqueous solutions or dispersions. In contrast to the older textile-coating resins for producing artificial leather and similar types of coated fabrics, these impregnating resins do not alter the surface appearance. However, they may greatly improve the tensile strength, resilience, durability, luster, and firmness of the fabrics. They impart to vegetable fibers many of the properties of animal fibers. Data are given to show the effect of applying different types of resins as well as of varying polymers of the same resin. The use of these water-dispersed synthetic resins is of increasing value and importance in the development of new and unique textile and industrial fabrics.

SYNTHETIC resins have been used for many years in coating lacquers applied to textile fabrics to produce oilcloths, tarpaulins, bridge-table covers, artificial leather, etc., and in each case the fabric merely acted as a backing or supporting material for a continuous, heavy lacquer film. In the last few years, however, an entirely new use of resins and plastics for the modification of textile fabric has grown up. In this application the resins are not used as coating materials but are impregnated into the fiber and may impart to the fabric improved properties of luster, strength, or resilience, but in each case the appearance of the fabric is not destroyed and the resin-treated fabric retains all of the properties of a textile with its characteristic porosity, absorbency, elasticity, flexibility, and serviceability. While this new method of modifying fabrics with resins frequently uses relatively low percentages of resins on the weight of the fabric, because of its far wider range of application, the total resin consumed in this field has grown to a point where it far exceeds the volume of coating resins previously used.

With this development of a new technique for the resin modification of textile fabrics, the object has been to improve or change some of the physical characteristics of the fabric without changing the appearance of the fabric. This development has proceeded so widely and so successfully that today there are fabrics which consist of 30 per cent synthetic resin and 70 per cent fiber, and yet they retain all of the appearance, feel, and even microscopic characteristics of a textile fabric made exclusively of natural or synthetic yarns. In other words, the resins are being impregnated into the individual fibers, and while they are modifying the properties of the fibers, they are not being used to coat the fibers like a lacquer or varnish. This new type of resin application is adaptable to all types of fibers and fabrics, and today there are millions of yards of cotton, rayon, wool, and silk fabrics which have been modified and whose serviceability has been improved by the addition of 1 to 30 per cent of specially developed synthetic resins.

The types that have been most successfully developed for this modification of textile fabrics are the clear, colorless, light-stable resins which can be dispersed or dissolved in water solution. It is necessary that resins of this type be used, for they must not alter the shade of the most delicate tint and must be applied from water to ensure thorough penetration and to avoid coating and lacquer effects. The same resin may be applied either as a surface coating from a solvent or from a water dispersion to give a lustrous finish, or from a water solution to give resilience and produce three entirely distinct effects, even though the composition of the deposited resin may be substantially the same. The important point is the location, distribution, and concentration of this deposited resin. Effects have been obtained by applying unpolymerized resins in aqueous solution and polymerizing them within the fiber that cannot be matched or duplicated by any other method of impregnating or treating, and it is this permeation of the low polymer resins into the fiber that has opened up a new and large field for resin application.

RESINS TO CHANGE CHARACTER OF FABRIC

It is possible to obtain a great variety of effects by the proper selection of resins and by varying the method of application. It has reached the stage today where a fabric may be modified or changed in as many ways with resins as it is possible to change it by varying the count, the twist, the type of fibers used, and the method of finishing. Resins are being used in large quantities to give rayon fibers the resilience of wool, cotton fibers the luster of silk, cotton fabrics the stability of a high-grade worsted, spun rayons the character and quality of high-priced woolens, and cottons and rayons the coolness and absorbency of linen. In addition to these effects, it is possible to improve the tensile strength, double or triple the wearing properties of the fabric, increase or decrease the elasticity and elongation of the yarns, increase or decrease the luster of the fabric, and improve the wash-

*Presented at the Detroit meeting of the American Chemical Society. Reprinted from, and halftones by courtesy of, Industrial & Engineering Chemistry.

**Röhm and Haas Company, Inc., Philadelphia, Penna.

ability and serviceability of the garments. The modern fabric designer must consider the use of resins in developing new and novel fabrics, for they are just as important today as the designer of twenty years ago considered the blending of animal and vegetable fibers and the variation of twist and yarn count. The use of synthetic resins in the modification of spun rayon fabrics has tremendously assisted the promotion of this fiber to the point where it is the most important development today in the suiting and dress goods field. Further application of resins will greatly increase the range of application of these spun rayon fabrics into new and unexplored fields.

These synthetic resins are being used as a part of the warp sizing to impart better wearing properties to the finished fabric. They are being used as binders for bright pigments to give better light fastness to the finished fabric. They are being used as finishing agents to improve the wearing and washing properties of all types of fabrics from the sheerest lawns to the heaviest drills.

DEVELOPMENT OF RESIN MODIFICATION

In tracing the development of synthetic resins for textile finishing, a great deal of credit goes to the Tootal Broadhurst Lee Company of Manchester, England, for the pioneer work in applying phenol-formaldehyde and urea-formaldehyde resins to cotton fabrics. They showed that unpolymerized urea-formaldehyde and phenol- formaldehyde resins could be impregnated and squeezed into the core of cotton and linen fabrics and, when polymerized in this position, produced fabrics with tremendously improved resilience. They further showed that if the surface or coating resin could be removed before it was polymerized, the resulting fabric was not stiffened and retained all of its initial suppleness, fullness, and drape. Their work goes back nearly fifteen years, but it was not until about seven years ago that they came to the United States with their anticrease process in an effort to license all of the large textile mills. While the development of this process has been slow in this country, there is no question but that it was the first successful application of resins to the modification of textile fabrics. This work was originally done on cotton fabrics, but it proved to be of tremendous value to the spun rayon fabrics which were developing for women's wear in 1935. Millions of yards of fabrics containing 10 to 15 per cent of urea-formaldehyde resin are on the market today. In no case does the fabric or fiber show any evidence of resin coating, and the treated fabric is as soft as, and occasionally softer than, the untreated and less attractive type.

In a study of the effect of some of these resins, we have treated a standard-construction cotton sheeting and a standard-construction spun rayon dress fabric with varying percentages of resins from aqueous solution or dispersion. In every case the resulting fabric has the same color and appearance as the untreated fabric. In every case the shade is unchanged. On the other hand,

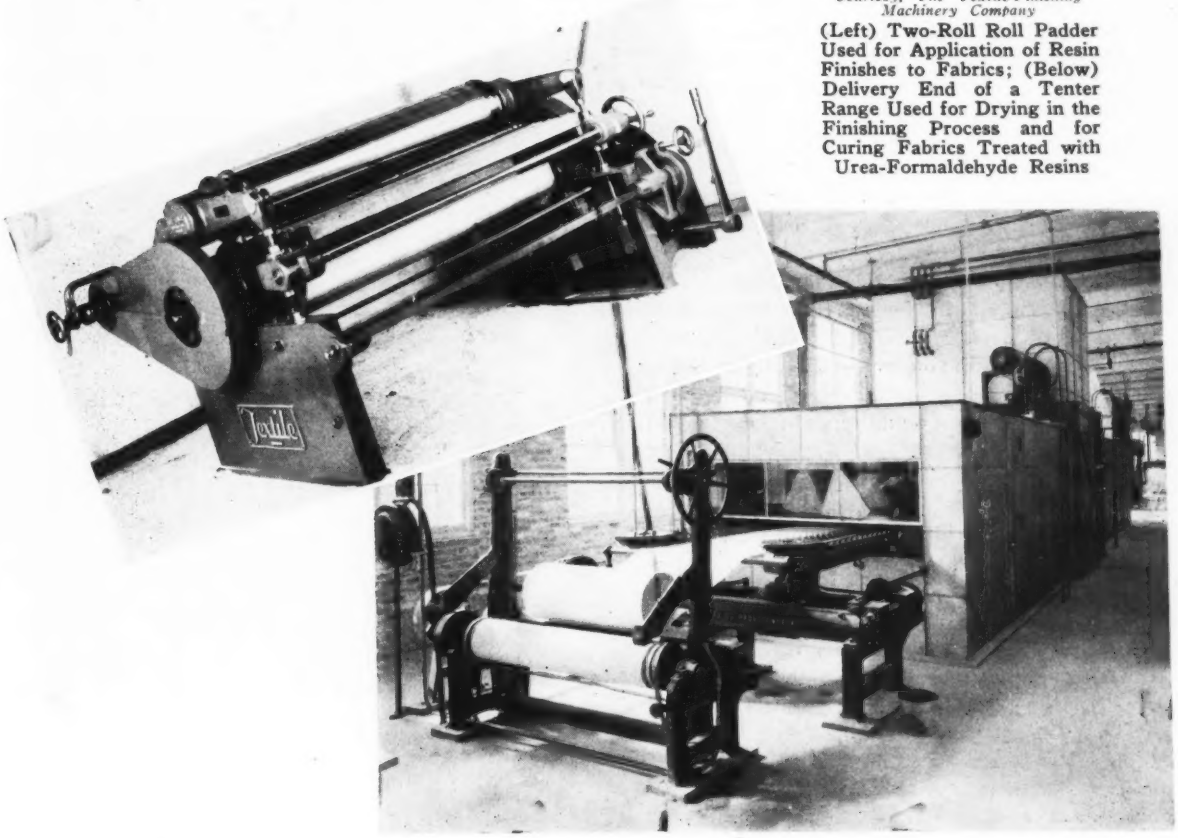
Velvet Finished with Urea-Formaldehyde Resin for Increased Resilience and Resistance to Crushing

the resilience of the fiber in certain cases was more than doubled. The abrasion resistance in some cases is increased fivefold. The firmness of the fabric is decreased in some cases and tripled in others. The elongation is decreased as much as 50 per cent and may be increased by the same figure. Some of the results obtained are tabulated here; we should emphasize that in each case the resulting fabric, when handled and examined in a cursory way, would show no superficial variation in spite of large changes in elongation, wear resistance, and durability.

APPLICATION OF UREA-FORMALDEHYDE RESINS

Urea-formaldehyde resins are of particular interest for textile application because of their clarity and light stability and because of the ease of their application from aqueous solutions. However, it is important that they be applied in exactly the right way, since their extreme brittleness will stiffen and tender a fabric and greatly reduce its wearing qualities if it is not correctly impregnated. Brittle surface resin will ruin the appearance and handle of any fabric, and only after years of experimenting can the textile mills now handle these stiff resins without fabric embrittlement.

Effect of Squeeze. Fabrics were treated with a 9 per cent aqueous solution of low-polymer urea-formaldehyde resin and with an 18 per cent solution of this same resin. The fabrics were run through the 9 per cent solution with a light squeeze and through the 18 per cent solution with a tight squeeze so that the actual resin content of the



Courtesy, The Textile-Finishing Machinery Company

(Left) Two-Roll Roll Padder Used for Application of Resin Finishes to Fabrics; (Below) Delivery End of a Tenter Range Used for Drying in the Finishing Process and for Curing Fabrics Treated with Urea-Formaldehyde Resins

fabrics was the same in both cases. After impregnation, the fabrics were dried and cured for 5 minutes at 300° F. to insolubilize the resin. The following table shows the differences obtained in these two fabrics having the same resin content:

	Tensile Strength, Lb./Sq. In.*	*Elongation*, %*	*Crush Resistance†*	*Abrasion Resistance‡*
Original fabric	120	23	2.5	2100
9% soln. light squeeze	121	20	3.0	960
18% soln., tight squeeze	131	24	3.3	1460

* Tensile strength and elongation were tested on a Scott machine. Figures are averages of five breaks using 1-inch jaws and a 3-inch gap.

† Tested according to Tootal Broadhurst Lee specifications; results are a mean of three tests. All fabrics were tested after conditioning for at least 8 hours at 76% relative humidity. A good worsted will have a crush resistance value of 2.8-3.2.

‡ Tested in accordance with Tootal Broadhurst Lee standard; test piece rotated under a given load at high speed against a heavy worsted fabric of standard construction.

Effect of Concentration. Where the fibers are impregnated with a low-polymer resin, the concentration applied is extremely important. Each fiber or fabric seems to have a saturation point or limiting concentration which it will hold. When applying higher concentrations, the excess seems to spill over and thus give brittle surface effects, poor abrasion, and fabric stiffness. This saturation point seems to be dependent on a great many factors, such as the twist of the fiber, the tension on the yarn during weaving, and the depth of shade to which it has been dyed. Yarns which have been dyed in heavy shades, particularly with sulfur colors, take much less resin into the fiber. As a rule, mercerized yarns will hold more resin than unmercerized yarns, and rayons will consistently hold more resin than cottons or linens. The use of penetrating or wetting agents frequently improve resin pickup by the fibers, since they undoubtedly cause a swelling of the fibers.

The following table shows the effect of increasing resin concentration; in each case, a point of maximum value is noted and higher concentrations give a sharp reduction in effects and tend to coat and embrittle the fabric:

*Stiffness of Fabric**		*Resin Content of Fiber, %*	*Tensile Strength, Lb./Sq. In.*	
Cotton	*Spun rayon*		*Cotton*	*Spun rayon*
2.0	2.0	0	118	120
2.1	2.2	1.0	114	124
2.1	2.4	3.0	112	127
2.4	2.5	8.0	98	130
9.4	3.6	20.0	86	114

* Calculated on basis of the original fabric having a value of 2.0 (1.0 in the warp and 1.0 in the filling). The values are l^4/t ratios compared with the l^4/t ratio of the original fabric, where l is the distance between supports and t is the amount of sag of sample. A difference of 0.2 is detectable in touching the fabrics.

Effect of Nature of Resin. It would be expected that entirely different effects could be obtained with different types of resins; but it is still more interesting to note that when urea-formaldehyde resins are applied in different degrees of polymerization or dispersion, they will give entirely different effects when used in the same concentration. The following table shows the effect of applying identical resin concentrations, but a variation of physical form of the resin and consequently a variation in the location of the deposited and polymerized resin. In each case the resin was applied from aqueous solution or dis-

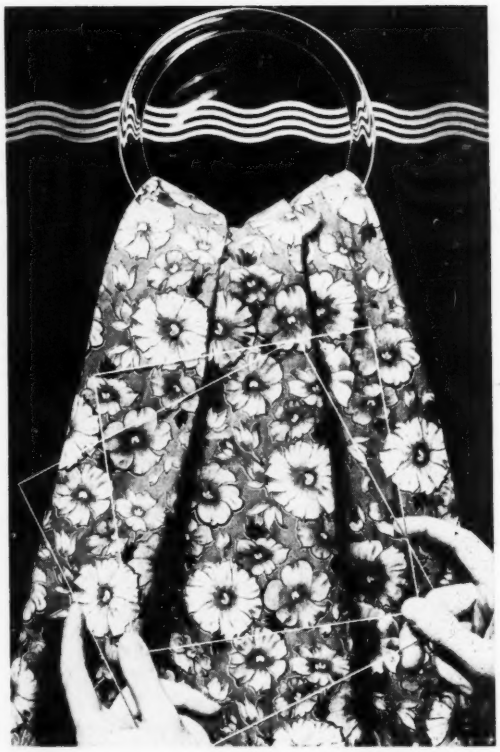
persion, squeezed into the fabric with a tight nip, and dried and cured in the usual way:

Type of Urea-Formaldehyde Applied	*Abrasion Resistance*	
	Cotton	*Spun rayon*
Control	3,000	2300
True water soln.	3,500	2200
Intermediate polymer in true soln.	2,200	2700
Intermediate polymer in colloidal soln.	1,000	4100
Higher polymer in colloidal dispersion	7,000	3100
Very high polymer in colloidal dispersion.	14,000	2800

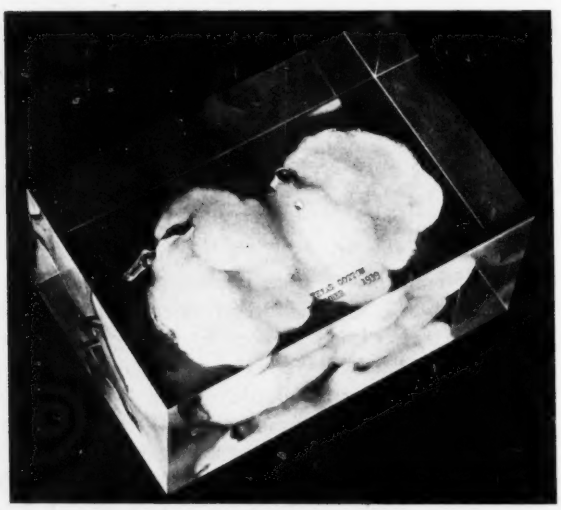
All of the other properties of the cotton and spun rayon fabrics changed markedly with the different types of resin used, but the relative resistance to abrasion of the treated fabrics offers a single value showing the great variations possible with the same concentration of the same resin. It should also be emphasized that each type of fiber and each fabric offers a separate problem, and so general conclusions cannot be drawn regarding the effect of any one type of resin on all types of fabrics or fibers.

APPLICATION OF ACRYLATE RESINS

While the urea-formaldehyde type resins are interesting because of their ease of application from aqueous solution in low or high degree of polymerization, other resins are finding general application for the modification of textile fabrics. One of the most important classes is the acrylates. These resins are valuable because of their clarity, freedom from color, and stability to oxidation and aging. The general use of these acrylates for textile processing has been made possible by a unique method for their polymerization and dispersion in aqueous solution in the absence of any organic solvents or plasticizers. As a result of this process it is possible to prepare an extremely fine colloidal dispersion of an acrylate resin which is very hard and tough or very soft and plastic. These dispersions are unique and entirely different from the emulsions which may be prepared by emulsifying solvent solutions of highly plasticized resins in the presence of large percentages of emulsifying and stabilizing agents. Impregnating a textile with a solvent-free dispersion of a hard acrylate resin has no stiffening action whatsoever. It gives the same effect as treating a fabric with a 5-10 per cent dispersion of kaolin, with the tremendous difference that the resin is clear, colorless, and transparent, and may be embedded between the fine filaments to improve their tensile strength, durability, and wearability. They may improve resilience, but since the resins themselves are not brittle one does not encounter the problem of embrittlement which must be constantly guarded against when working with urea-formaldehyde resins.



Two Sheets of Acrylate Resin Placed in Front of a Fabric to Indicate the Crystal Clarity of This Type of Resin



Cotton Bolls Embedded in Acrylate Resin by Process Developed by Charles E. Sando of the U. S. Department of Agriculture

The following table shows the influence of varying the hardness of the acrylate resin dispersed in water. Here again the effects are different on cotton from those on spun rayon, and no general conclusions should be made as to the results obtained with any given resin:

	Tensile Strength, Lb./Sq. In.		*Abrasion Resistance*		*Stiffness of Fabric*	
Resin Type	*Cotton*	*Spun rayon*	*Cotton*	*Spun rayon*	*Cotton*	*Spun rayon*
Control	131	121	3,000	2000	2.0	2.0
Hard acrylate	132	128	10,000	3000	4.0	4.0
Medium acrylate	130	141	9,000	5000	2.8	3.6
Soft acrylate	121	134	15,000	4000	2.3	2.1

In each series the same concentration of resin was deposited in the fabric. These changes were produced with resin concentrations as low as 2-3 per cent. In general, it has been found that low concentrations of the acrylates have more effect on the properties of the fabrics. On the other hand, it is usually possible to incorporate higher percentages of the urea-formaldehyde resins without stiffening or firming the handle of the fabric.

(Continued on page 76)

Cotton Fiber—

(Continued from page 60)

It soon became clear that there was a relationship between the optical differences and fibril reversals on the one hand, and balloon-formation on the other. In *concentrated* cuprammonium hydroxide solutions (reagent diluted not more than 3 times with concentrated ammonia) dissolution of the cellulose of the fibers took place in a relatively short time. The fibers appeared to break into large chunks which became progressively smaller as dissolution proceeded. Observed between crossed nicols the highly birefringent fibers were seen to break up into fragments which steadily became less birefringent until the field of the microscope was black. In *dilute* solutions (diluted between 3 and 10 times) the fibers swelled greatly but complete dissolution generally did not occur. As swelling took place balloons were occasionally formed. When the behavior of the fibers was observed with crossed nicols the fibers were seen to become progressively dimmer as the cellulose dissolved. The expanded part of a balloon was the first to lose its birefringence, since here the cellulose had become highly disorganized. On the other hand, the constrictions were slow in losing their anisotropy (Fig. 11, A), since the reagent penetrated these regions

Figure 10. Depectinized fibers swollen in dilute cuprammonium hydroxide solution and handled with micro-needles.
A. A single fiber being dissected with micro-needles to show fibrillar structure.
B. Fibrils being pulled away from the fiber. (The needles are not shown in the photomicrograph).
Magnification X 500.

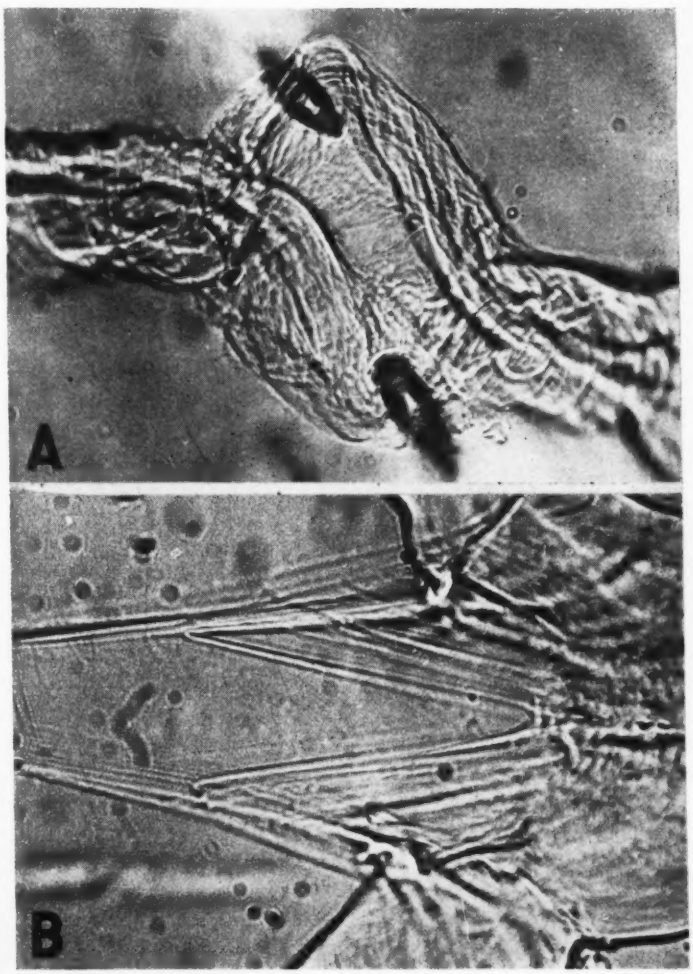
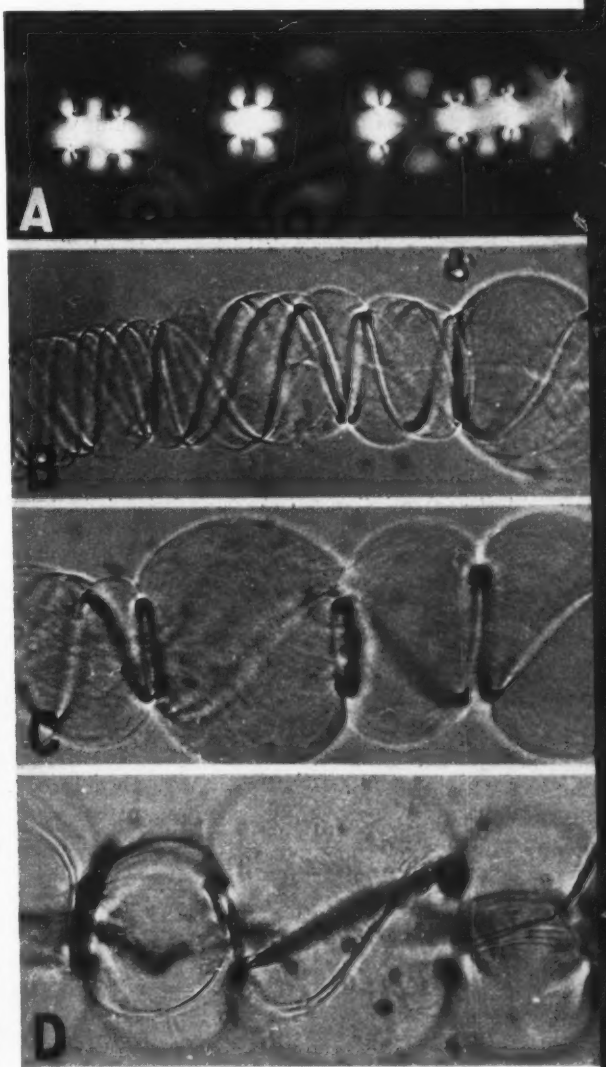


Figure 11. Cotton fibers swollen in cuprammonium hydroxide solution to produce balloons.
A. Depectinized fibers showing balloons, photographed between crossed nicols. (selenite plate inserted).
Magnification X 260.
B. Depectinized fibers showing winding. The coarse appearance of the winding may have resulted from the coalescence of individual fibrils during incipient balloon-formation.
Magnification X 420.
C. Typical string of balloons in a depectinized fiber.
Magnification X 500.
D. String of balloons in a raw fiber showing the winding and fragments of the primary wall connecting the constrictions. Fiber stained with ruthenium red.
Magnification X 440.



slowly. When fibers which had lost much of their birefringence during swelling in cuprammonium solution were placed in water, some of the original birefringence of the fibers, as well as some of their fibrillar appearance, was restored.

The occurrence of balloons in *depectinized* fibers was somewhat surprising, since experiments by ourselves and by others indicated that the primary wall plays an important role in the formation of balloons. Accordingly, the phenomenon was studied further, especially in depectinized fibers from which the wax and pectic substance had been removed. The optimum concentration of cuprammonium hydroxide solution for observing balloons in these fibers was between 15 and 20 per cent (1.5 to 2.0 ml. of the reagent diluted to 10 ml. by the addition of concentrated ammonia). When depectinized fibers were placed in these solutions they often swelled unevenly along the axis, thereby giving rise to balloons (Fig. 11, B and C). The expanded portion of the balloons almost invariably occurred between the points at which the fibrils reversed, whereas the reversal points themselves formed the constrictions between adjacent balloons. Fragments of depectinized fibers which showed no extinction bands usually swelled without the formation of balloons, and the direction of the fibrils was found to be constant. Because of the orientation of the cellulose within the fiber, the greatest swelling occurs perpendicular to the fiber axis, while at the same time there is an actual decrease in fiber length. As these changes in length and in width take place, the winding assumes a more transverse position (Fig. 11, B) and becomes clumped at the constrictions. However, the uniform lateral expansion of the fiber is hindered somewhat by this same winding which does not expand freely in that direction. Accordingly, the winding appears to exert a constricting influence on the swelling of the fibers.

It has been recognized that the primary wall is responsible, at least in part, for the formation of balloons. The rupture of this wall into a series of constrictions which restrains the expanding cellulose, has frequently been described. Furthermore, fragments of *raw* fibers which show uniform optical characteristics often produce many balloons as swelling occurs, whereas similar fragments of depectinized fibers do not produce balloons. When balloons are formed in raw fibers the cellulose fibrils may push through the winding and the primary wall, so that a constriction consists of a clump of the winding as well as of a portion of the primary wall (Fig. 11, D). Thus, the above experiments suggest that the irregular swelling along the fiber axis, which frequently results in balloon formation, is dependent in part on the orientation of the fibrils and in part on the constricting influence of the winding and of the primary wall.

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Resins and Plastics—

(Continued from page 74)

OTHER RESIN TYPES

While the urea-formaldehyde and the acrylate resins are the most important and most generally used on textiles because of their clarity and ease of application, other types, such as the alkyds, vinyls, and styrenes, are finding an increasing application, particularly where they produce certain specific effects. The following table gives a general comparison of the effects which may be obtained with the same concentration of different type resins on textiles fabrics:

Type of Resin	*Stiffness**	*Resilience†*	*Durability‡*	*Tensile Strength§, Lb./Sq. In.*
Control	2.0	2.3	10	51
Urea-formaldehyde soln.	2.4	3.2	11	47
Urea-formaldehyde dispersion	4.0	2.7	45	61
Hard acrylate dispersion	11.7	2.6	36	62
Soft acrylate dispersion	2.3	2.7	48	64
Hard alkyd dispersion	2.2	2.5	42	61

* Directly proportional to the control, which is given a value of 1.0 for warp stiffness and 1.0 for filling stiffness. The values are I^4/l ratios.
† Measured by Tootal Broadhurst Lee procedure on a fabric which has been conditioned at 76% relative humidity for 8 hours.
‡ Relative resistance to rubbing at high speed as compared with a standard untreated test piece.
§ Tested on a Scott machine with a 1-inch jaw and a 3-inch gap.

Here again no general conclusions can be drawn as to which resin is the best suited for any particular purpose. It is, however, increasingly clear that resins may be used to improve the physical properties of textile fabrics greatly. For industrial application the use of resins is particularly important as it makes possible the development of fabrics to fit a wide range of specifications at a minimum cost. Since the resins are permanent and durable, they will usually last the life of the fibers themselves and in a great many cases greatly prolong the life of the fibers. As we learn more about the factors contributing

to the tensile strength of yarns, we can reasonably expect to produce from cotton, rayon, or spun rayon, fabrics with all of the properties of woolens and worsteds and none of their susceptibility to attack by alkalies or moths. By the same token the use of resins on wool is similar to its action on spun rayon, and correspondingly improves the durability without imparting harshness or brittleness.

The year 1940 has seen the production of a number of fabrics which could never have been sold in the particular markets which they captured without the use of synthetic resins as a necessary part of their fibers. It is reasonable to expect that the next decade will see resin-modified fabrics competing and replacing on rapidly widening fronts the conventional textile fabrics whose properties were determined by their thread count, fiber length, and yarn twist. Today it is possible to alter a fabric as greatly by resin treatment as formerly required a fiber substitution of wool for cotton or silk for rayon.

ORGANIZED RESEARCH NEEDS ORGANIZING

(Concluded from page 69)

developed sufficiently. Some never would be submitted had they been developed further and their futility discovered. Others might lead to new ideas which would be effective.

If all new ideas could be circulated among all research workers, both those engaged in organized research and those in independent, individual research, it is probable that much more and effective progress could be made.

In the final analysis modern warfare is fought and won by ideas. In Germany they had ideas in regard to the kind of machines which would be most effective in war and in regard to producing them. The military leaders had ideas in regard to the best way of actually using those machines in warfare. It would seem that the idea of preparing and then conquering at least a considerable part of the world took root in that nation. At any rate all research and all labor, all brain power and all brawn power was mobilized toward one objective. For a time it looked as though the idea would be carried out. Perhaps it would have been had it not been that the English Channel served to give England time to prepare in earnest to meet the situation.

There is no doubt that Germany's ability to mobilize all research effort toward her one end proved an advantage at the start. There is also no doubt that the driving out of the country, before the war, of some of her eminent scientists and research workers proved a weakness. She not only lost the services of these men but the countries she was fighting obtained their services. So, after all, there was not complete mobilization of scientific and research talent.

One way of securing the very best results in this country is to have available the names and addresses and qualifications and past work of all those engaged in any kind of research: those who are in organized research, those to whom research is merely a hobby, those who are more or less free lances. Miracles can be accomplished if the right combination of workers in the required number of fields work together on any given project. This does not mean they have to work in the same place. It does mean that each person work on the solution of the particular problem or part of the problem which he is best fitted to solve.

The experience, qualifications, etc., of those who belong to national engineering and other associations are being gathered and placed on file in central offices. In this way it is hoped that those needed can be discovered when the need arises. Not so much co-ordinated effort in the direction of discovering and making practical new and effective ideas may be possible. If to every action there is an opposite and equal reaction it should follow that for every instrument of offense, there is an opposite and equally effective one of defense. In other words no means of offense can be developed against which there cannot be developed so effective a defense as to make it largely ineffective.

Since this war is being fought through the medium of research, effective defense must come through the medium of research. If our defense program is going to be most effective then much more of the research genius in this nation than is likely to be the case must be drawn upon or its products be forced upon the government. If we are going to prepare for a defensive war we must depend to a marked degree upon research. If we are going to continue free enterprise in the United States we will have to co-ordinate research talent in some voluntary manner toward the end that better results can be obtained than are possible in any totalitarian nation. That system which secures the best results is the one which endures. During the past century and a half the free enterprise, the individual initiative system has served well in the United States.

Today, however, that system is on the defensive. There are those high in government circles who do not appear to have any too much faith in it. Foreign nations have their agents among us endeavoring to break down our faith in it. One of the great present needs, therefore, appears to be more effective voluntary co-ordination of any talent and effort which can help strengthen our defense and make any aid we may be called upon to give in winning the present war more conclusive. Back of all the strength of offense or defense is research. The main reason why Germany is able to dominate her axis partners is that she is stronger in research than they are. We should be stronger than any other nation provided we are able to focus our research ability on any given problem as it arises. The organizing for this can be done voluntarily and independent of the government. That way it is likely to prove most effective because it is freer of politics. It can be organized in the totalitarian manner but that might mean driving out of the country research talent which may be needed badly at some later time.

OBITUARY

WILLIAM P. PICKHARDT

WILLIAM PAUL PICKHARDT, senior vice-president and a director of the General Aniline and Film Corp., died on January 22nd in the Lenox Hill Hospital, New York, after a short illness. He was 60 years of age.

Mr. Pickhardt was born in New York and was a son of the late Carl Pickhardt.

Kaiden Kazanjian

WILLIAM P. PICKHARDT

He was graduated from the Gymnase Cantonale de Neuchatel, Switzerland, and received a B.S. degree in chemistry from Columbia University in 1901. He started as a salesman in New England for his father's firm, Kuttroff, Pickhardt & Co., importers and manufacturers of dyes and chemicals. He later became secretary and a director of the company and in 1925 was made president, which position he held until 1930 when a reorganization took place, and several new concerns were formed.

From 1930 to 1938 Mr. Pickhardt was chairman of the board and a director of the Synthetic Nitrogen Products Corp. and also had been a director of General Dyestuff Corp. From 1935 to 1938 he was president of Chemnyco, Inc., and from 1932 to 1936 was president and a director of Unyte Corp. He was also a director for many years of the Plaskon Company, Inc. He was shortly to have been elected chairman of the board of the General Aniline and Film Corp. He was formerly chairman of Agfa Ansco Corp. until its recent merger with General Aniline.

Mr. Pickhardt was not married. He is survived by his mother, Mrs. Paula von Scheven Pickhardt, two brothers, Dr. Otto C. Pickhardt and Captain Adolph von S. Pickhardt, U.S.N., and three sisters, Mrs. Dorothy P. Kahle, Mrs. Edith Colman and Mrs. Elsa Kuller.

• GENERAL RELEASES

General Dyestuff Corp., 435 Hudson Street, New York City, announces release of circulars describing the following products:

Calco's Effluent Plant. Portion of 60 Million Gallon Settling Basin in Foreground.

Para Brown RBA Extra Conc.—A direct dyestuff which produces full shades of reddish brown when coupled with Nitrazol CF Extra. It is well suited for the dyeing of cotton or rayon, both piece goods and yarn, and is said to produce shades of good fastness to water, to perspiration, to hot-pressing, and to washing. It can be discharged to a good white with Rongalite C. It is stated that the dyeings form an excellent ground for white or colored discharge styles which must withstand washing. Circular G-220.

Celliton Fast Blue FFRS Extra Conc.—a dispersed, direct dyeing acetate blue of an exceptionally bright shade. It is said to possess excellent dyeing and penerating properties and to have good affinity even at low temperatures. It is suited for dyeing on the jig or in the box for the production of a variety of shades of blue. It is stated that, on account of its advantageous dyeing properties, it enters into useful combinations with related products to yield navies, greens and browns. Circular G-219.

Katigen Crossdye Green BG-CF—a sulfur color which produces fairly bright shades of green. It is said to be valuable both for self shades and for combinations with other sulfur colors. It dyes cotton or rayon in all their stages of manufacturer, i.e., rawstock, hanks, packages, beams and piece goods. The dyeings are said to possess good fastness to washing and good to very good fastness to light. The product is well suited for machine dyeing and can be used on material which is to be rubberized after dyeing. Circular G-217.

• CALCO SUMMARIZES 1940 PROGRESS

Important new additions to plant and equipment are reported to have been completed in 1940 by the Calco Chemical Division, American Cyanamid Company. Among the new units placed in operation by this organization, are a 60 million-gallon effluent plant, the first unit of a new pharmaceutical building, a new power plant addition, and a 970-foot warehouse. During 1940 also, a modern, air-conditioned employees' cafeteria, and an addition to the group of tar acid stills were made.

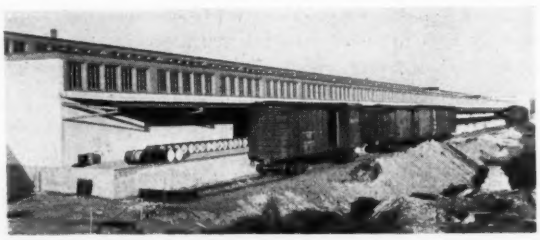
The new effluent plant was designed to thoroughly treat Calco's acid, odorous and colored effluent after several years of intensive research and experimentation with a $40,000 pilot plant. Because of Calco's peculiar waste problem, this plant makes use of features never before employed for this purpose. The successful operation of this plant was witnessed by State officials at a celebration in November.

Calco also completed and placed in operation during 1940 a warehouse 970 feet in length. This structure, made necessary by the inadequacy of the present warehouse, is featured by a railroad siding entering the interior of the building.

To provide an increased supply of naphthalene, anthracene and phenol, a complete still unit was added to those in the tar acid group. 1940 also saw the power plant enlarged with a new boiler and generating unit. The latter, a 2,500-kw., 475-lb. pressure turbine, increased the existing capacity by 50 per cent.

During the past twelve months Calco has commenced the construction of a new building in which will be located a greatly expanded pharmaceutical department. In December the first section of this new building was placed in operation. Embodying many new features of design to promote efficiency and cleanliness, the new section also has incorporated in it a new control laboratory and additional research facilities, as well as a pilot plant of advanced design.

In another building a new employee cafeteria was completed for use in June, 1940. Stainless steel and Monel metal fixtures insure cleanliness in the handling of food. The cafeteria is air-conditioned and is equipped throughout with flush lighting fixtures and a sound-absorbing ceiling.



Calco's New Warehouse Building

● TRANSPARENT IDENTIFICATION TAG

What is probably the first scientifically designed tag for use in fabric identification has been adopted by the American Viscose Corporation to label garments made from Crown Tested Rayon Fabrics. This new tag, developed in accordance with suggestions received in a nationwide survey of retailers, differs from conventional tags in many important respects.

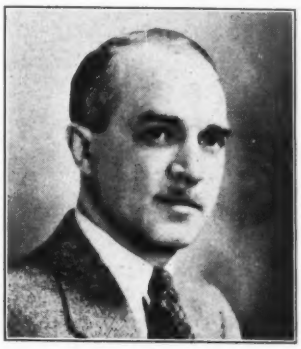
It is transparent—assumes the color of the garment. It bears only essential information about the fabric, no advertising copy about the yarn manufacturer, weaver, dyer, or finisher. It is of simple rectangular shape with rounded corners. Its only embellishment is the golden crown and the slender golden cord on which it is suspended. It is stated that retailers' objections to the principle of fabric identification have been few, but their objections to tags supplied by over-zealous producers have been all too numerous. For this reason, American Viscose Corporation surveyed the entire retail field before designing this newest tag. 5,084 questionnaires were mailed to retail stores of all sizes and types, in all parts of the country, and from retailers' own frank criticisms, the new transparent tag was designed.

At this time, American Viscose Corporation plans to supply these tags exclusively for dresses wholesaling at $6.75 and up. Plans have already been made to extend use of the transparent tag to lower price levels as soon as it attains its anticipated popularity in the higher price garments.

New "Crown Tested" tag scientifically designed by Donald Deskey, famous industrial designer. This is said to be the first tag constructed of transparent plastic material.

● JOINS ONYX

H. Russell Haley has been appointed to the staff of the Onyx Oil & Chemical Co., Jersey City, N. J., in the capacity of technical advisor. He will work direct with the mill and commission dyers and finishers and his work in the field will be coordinated with the Onyx general and research laboratories. Mr. Haley was formerly connected with the firms of J. H. & C. K. Eagle, Cheney Bros., and the Sunbury Converting Works. He is well versed in the boiling-off, dyeing and finishing of all fabrics, particularly synthetic fabrics, having made an extensive study of the synthetic field for a number of years.



H. RUSSELL HALEY

● FLAME-PROOFING TREATMENT

A "flame-proofing" treatment for draperies, children's and women's dresses, mattress coverings, and other textile fabrics was described on January 14th to the National Retail Dry Goods Association by Dr. W. E. Gordon, DuPont Company chemist.

Increased use of pile fabrics, with fuzzy, inflammable surfaces, has emphasized the need for an effective retardant treatment, Dr. Gordon said. The treatment does not "fire proof" the cloth, but substantially reduces its susceptibility to bursts of flame which often cause serious damage and injuries. He demonstrated that treated fabrics will merely char when subjected to fire, and contribute nothing to the general blaze.

"Fire retardant chemicals have been known more than a hundred years," Dr. Gordon pointed out, "but for various reasons these have never been found entirely satisfactory. Recently, Du Pont chemists developed a practical method for manufacturing a compound, known as ammonium sulfamate, which possesses valuable flame-proofing characteristics. After considerable research this compound was adapted successfully for practical use.

"Treated fabrics," said Dr. Gordon, "are not stiffened or made harsh to the hand. Their appearance is unaltered, and the loss of strength is negligible. The compound is applied in a water solution. No special equipment is needed.

"The fire retardant properties of treated fabrics are not lost after repeated dry cleanings," he added, "although they are removed by laundering. However, the fire retardant may be re-applied in the same manner as one normally applies starch in the last rinse water. Many laundries already offer this service."

The minimum retention of fire retardant needed to impart good flame-proofing characteristics varies with different textile fibers and construction, Dr. Gordon disclosed. With one type, pure silk requires an average retention of 10 to 16 per cent, viscose rayon 12 per cent, cotton and linen 10 per cent, and wool 6 per cent. Nylon and heavily weighted silks are essentially flame-proof without treatment. These figures, however, do not necessarily represent the degree of hazard, he warned. With normal use a fabric of open construction or with a fuzzy pile offers a much greater fire hazard than one with a tight construction or a smooth, hard surface.

● ELECTRON MICROSCOPE

America's first commercially built electron microscope, which enables scientists to picture minute objects at 100,000 times natural size, is now being operated in the Stamford Laboratories of the American Cyanamid Company, Stamford, Conn. It is stated that, although several experimental microscopes of the kind have been built and used, the first American commercial instrument is being used by American Cyanamid's scientists to develop new chemicals for industry and medicine. The instrument was developed and built by the RCA Research Laboratories in Camden, N. J.

Photographs made directly in the electron microscope show the object magnified 20 to 30 thousand times. However, details are so clearly pictured in these photographs that they can be readily enlarged to give a total useful magnification of 100,000 times natural size. An average human hair subjected to such huge magnification would appear to have a diameter as great as California's giant trees, and an object an inch long so magnified would appear to be more than one and one-half miles in length. The limit of magnification of the best optical microscopes is about 1,000 times natural size.

Photographs made in preliminary tests of the instrument show what are presumed to be individual giant molecules, the shapes and sizes of colloidal particles, and intimate details of certain types of bacteria, which the weaker power of optical microscopes could not reveal.

Applications of the new instrument in the American Cyanamid laboratories are

expected to uncover new and important facts about the action of catalysts; about the action of chemicals on the bacteria of disease, and about the nature of synthetic resins and the processes by which they are formed. Other fields in which the laboratory is actively engaged, and to which the new instrument will be applied, include the flotation of ores and the recovery of metals by cyanidation; the manufacture of special chemicals used in the leather and paper industries; the treatment of textiles; rubber chemicals and their action in prolonging the useful like of rubber goods; synthetic resins, and plastics and enamels into which they enter; insecticides and fungicides, important to agriculture in the control of insects and diseases of plant; fertilizers and plant hormone substances; and a wide variety of chemical products, many of which are made from the company's basic raw material, calcium cyanamid.

• TECHNOLOGISTS NEEDED BY THE GOVERNMENT

The United States Civil Service Commission has announced open competitive examinations to secure technologists for national defense work. Difficulty is being experienced in filling positions in such branches of technology as explosives, fuels, plastics, rubber, minerals, and textiles. Persons qualified in these branches are particularly urged to file application.

The positions to be filled are in several grades with salaries ranging from $2,000 to $5,600 a year. For the lowest grade, that of junior technologist in any specialized branch, applicants will be required to take a written general test. For the other grades, competitors will not have to take a written test but will be rated upon their education and experience.

The duties of the higher grade positions include the planning, conducting, and reporting of investigation or research in a specialized branch of technology; or the testing, designing, or manufacturing of the materials essential for the successful operation of an industrial plant. For the junior grade, the duties are to perform scientific work in a branch of technology such as ceramics, minerals, paper, petroleum, rubber, or textiles. All applicants must have completed a 4-year college course with specialized major study required for all but the junior grade, appropriate experience in the field of technology must also be shown.

Applications for the position of junior technologist must be filed at the Commission's Washington office not later than February 20 if sent from States east of Colorado, and February 24th, 1941, if sent from Colorado and States westward. For the other technologist positions, applications will be rated as received until December 31, 1941. Further information and application forms may be obtained from the Secretary of the Board of U. S. Civil Service Examiners at any first- or second-class post office, or from the U. S. Civil Service Commission, Washington, D. C.

• COWLES OFFICERS ELECTED

At a meeting of the Directors of The Cowles Detergent Company recently the following new officers were elected:

E. N. Horr, Vice-President and General Manager; C. C. Bassett, Vice-President and Director of Sales; C. C. Barrett, Secretary and Treasurer; C. H. Fisher, Ass't Secretary and Ass't Treasurer.

These new officers take office immediately. Mr. Horr has been with the company since 1925, most recently in charge of production and purchasing. Mr. Bassett has been with the company since 1931 and has managed the Mitchell Wing division at Cambridge, Mass., since 1932. Mr. Barrett has been Secretary of the company since 1927, and Mr. Fisher has been tax specialist and accountant since 1929.

• BOOK ON TEMPERATURE

It was announced last year that a book on "Temperature—Its Measurement and Control in Science and Industry" was in preparation to make permanently available the valuable papers presented at a symposium on this subject sponsored by the American Institute of Physics with the cooperation of the National Bureau of Standards and the National Research Council, held last winter in New York. This monumental volume will be ready for distribution about the middle of February. The original papers have been carefully edited by authorities in their fields. They have also been rearranged, supplemented and exhaustively indexed. All phases of temperature are covered in great detail. By special arrangement the book is to be published by the Reinhold Publishing Corporation, 330 West 42nd St., New York City, at a list price of $11.00 per copy. A valuable appendix of 25 reference tables is also included and this may be purchased separately bound for $1.00 per copy. With introductory material and indexes, the volume runs to 1375 pages. It will be especially valuable for chemists, teachers, physicists, biologists, medical men, metallurgists, geologists, electrical, mechanical and refrigerating engineers, and plant operating officials.

• JOINS WARWICK

In a further effort to expand its services, the Warwick Chemical Company, West Warwick, R. I., announces the appointment to its sales staff of Parke Masters, formerly with the R. & H. Division of the DuPont Co. and with the Joseph Turner Co. of Richfield, N. J. Mr. Masters comes to Warwick with years of direct contact with the trade through traveling.

• CLASSIFIED ADVERTISEMENTS •

The rate for "Position Wanted" advertisements in this column is 2 cents a word—with a minimum of 50 cents per insertion. For all other types of advertisements—i.e., help wanted, machinery or supplies for sale—the rate is $5.00 per column inch or less per insertion.

WANTED: COLORIST-CHEMIST screen textile printing. State experience. Opportunity for right man—out of town. Confidential. Write Box No. 293, American Dyestuff Reporter, 440 Fourth Ave., New York, N. Y.

POSITION WANTED: Textile School Honor Graduate, Chemistry and Dyeing. Age 24. Almost three years with present employer, in charge of dye-house laboratory, matching samples, analyzing and control. Looking for opening with future, any part of U. S. Write Box No. 294, American Dyestuff Reporter, 440 Fourth Ave., New York, N. Y.

POSITION WANTED: Executive and sales type of textile chemist and colorist desires position in sales, contact, promotional or supervisory work. Age 43, American, married. Factory, laboratory, office and purchasing experience. Textile school graduate. Good correspondent. Good personality. Accustomed to assuming responsibility and exercising initiative. 21 years' experience in the textile, chemical and dye industries. Opportunity most important. Now employed. Available on short notice. Write Box No. 290, Amercian Dyestuff Reporter, 440 Fourth Ave., New York, N. Y.